PIKIARIKI ECOLOGICAL AREA

ITS

PATTERNS, PROCESSES AND MANAGEMENT

A dissertation
submitted in partial fulfilment
of the requirements for the degree of
Bachelor of Forestry Science

BY

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ABSTRACT

Pikiariki Ecological Area is a dense podocarp forest remnant of the West Taupo lowland forest tract. Its forest supports one of New Zealand's more diverse and dense bird populations. Of significance among these birds is the kokako, one of the two surviving species of the endemic family Callaeatidae and now classified as 'vulnerable'.

Neither the forest nor the birdlife are stable within Pikiariki. Selection logging has left parts of the reserve wind-prone and its shape and size do not conform with that suggested as best according to island biogeography theory.

The problem of instability is aggravated by man-induced hazards: notably predators and browsing mammals. Rats and stoats pose a serious threat to kokako and other birds, while deer and possums compete for foods essential in the diet of the kokako. Recently kokako have shown poor reproductive success and this may largely be attributed to predation; however a lowering of the plane of nutrition may also be important.

Management will primarily look to preserving the kokako in Pikiariki but must also ensure that water values are protected. Recreation is of a small and specialised nature which can be accommodated with careful zoning and constraints. The ecology of the forest and its animals must be considered in management.

It is clear that eradication of noxious animals is impractical but locally control may be feasible. The effectiveness of control measures is largely unproven, however, and control operations must be closely monitored. For long term stability artificial re-establishment of indigenous flora is desirable.

Way back in the days when the forests were still green
Lake Taupo was wet
And the clouds were still clean
And the song of the kokako rang out in space ...
One morning, I came to this glorious place

And I first saw the trees!
The podocarp trees!
The beauty and glory of the podocarp trees!
Mile after mile in the fresh morning breeze

And in the trees, I saw the kokako
Hopping about in their blue feathered suits
As they played in the shade and ate podocarp fruits.

Exert from The Wildlife Officer And The Woodsman
by Kerry Underhill (in Juby, M. *et al*, 1984.
Environmental Education, A Source Book For Teachers.
Commission for Envt, Wellington).

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I. INTRODUCTION

The preservation of New Zealand's natural ecosystems has in recent times been a major concern for conservationists and forest managers alike. With the introduction of the 1973 Forest Amendment Act it became possible to set areas aside as Ecological Areas. The job of choosing which areas are to be reserved as Ecological Areas is a function of the Scientific Co-ordinating Committee, and they act upon a set of guidelines on suitability.

It was under this Act that in 1979, 457 hectares of podocarp forest was gazetted as the Pikiariki Ecological Area. Its wildlife values, including kokako, were recognised as 'outstanding' by the Wildlife Service. Peripheral forest areas continued to be logged until, in 1978, protest action brought a halt to all operations, and a three year moratorium was placed on all logging.

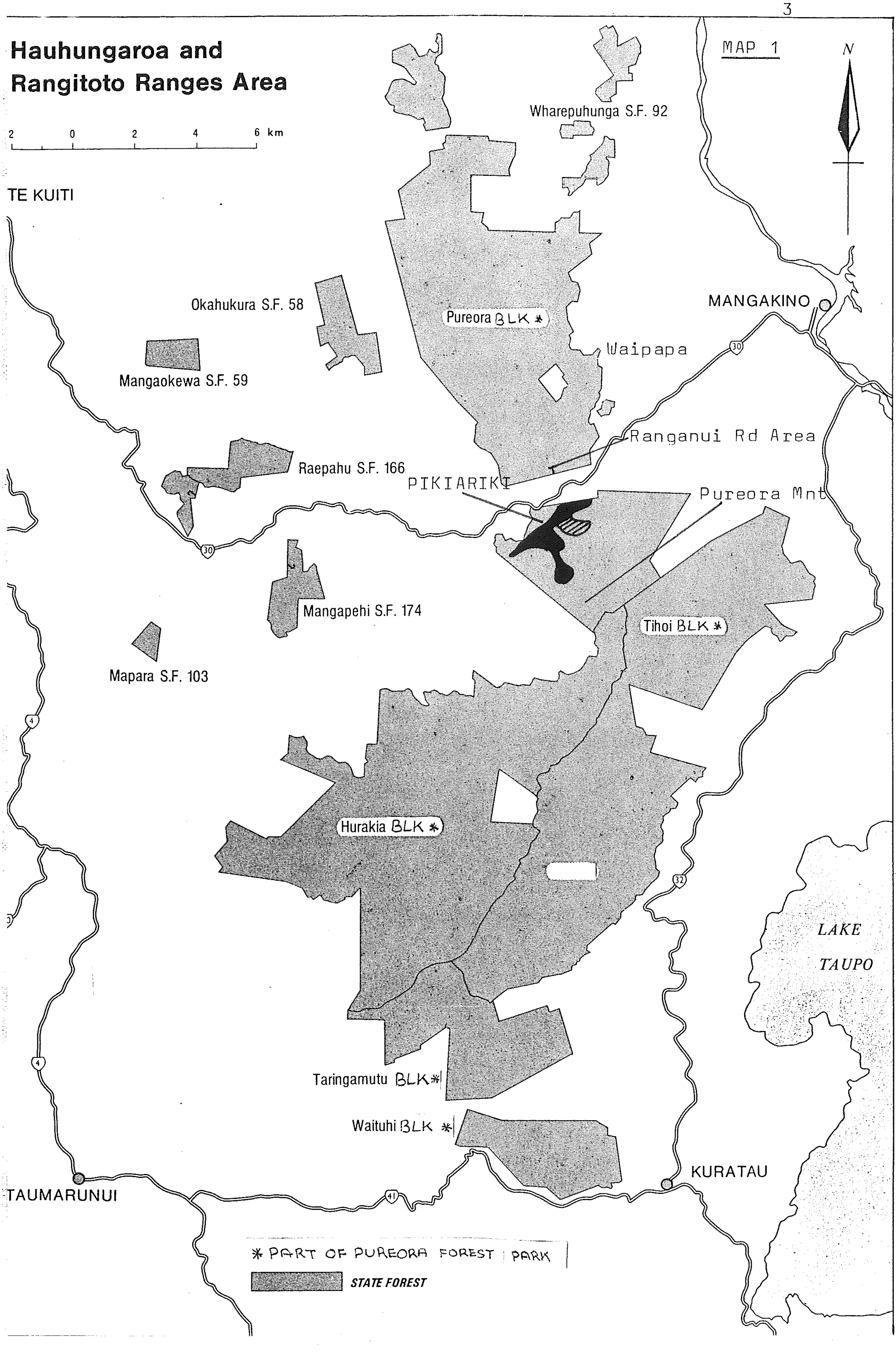
Research conducted over the three years by the multidisciplinary, Forest Bird Research Group (F.B.R.G.) revealed much about the forest ecosystem, with efforts concentrated on the kokako. The results described the feeding and breeding habits of the kokako and revealed that the birds' continued existence was uncertain due to the presence of introduced predators and browsing mammals.

The moratorium period expired in 1981, and it was decided that logging operations should not recommence.

Although this showed positive steps towards the conservation of kokako; recent knowledge of kokako habitat requirements indicates that the remaining area is insufficient to sustain kokako indefinitely.

Management must face these problems and at the same time satisfy other demands on the forest; these often conflicting. This requires the definition of the problems involved and then the formulation of a suitable solution.

This dissertation will attempt to define these problems and offer a suitable solution.


Hauhungaroa and
Rangitoto Ranges Area
MAP 1
N
2 0 2 4 6 km
TE KUITI
Wharepuhunga S.F. 92
Okahukura S.F. 58
Mangaokewa S.F. 59
Pureora BLK *
Waipapa
MANGAKINO
30
Ranganui Rd Area
Raepahu S.F. 166
PIKIARIKI
Pureora Mnt
30
Mangapehi S.F. 174
Tihoi BLK *
Mapara S.F. 103
4
Hurakia BLK *
32
LAKE
TAUPO
4
Taringamutu BLK *
Waituhi BLK *
TAUMARUNUI
41
KURATAU
* PART OF PUREORA FOREST PARK
STATE FOREST

2. SITE DESCRIPTION

2.1 Location

Pikiariki Ecological Area and adjoining indigenous forest areas are in Pureora State Forest Park (Map 1). They are situated south of State Highway 30 and adjacent to Pureora Forest Headquarters. This lies below Pureora Mountain and in a saddle between the Hauhungaroa and Rangitoto Ranges. Access to the reserve is attained via several forest roads; Pikiariki Road and Perhams Avenue are major forest roads which cross it.

2.2 Landform

The most recent, significant, land forming event has been vulcanicity. At the northern end of the Hauhungaroa range, where Pureora lies, the pattern is of ignimbrite deposits, of Taupo or Mokai origin, surrounding the greywacke capped Hauhungaroa and Rangitoto ranges. Between these ranges lie the adnesite capped Pureora and Titiraupunga mountains (McKelvey, 1963).

There has been periodic deposition of rhyolite, pumice and lapilli with the most recent eruption of Taupo, 1800 years ago, leaving a uniform, compact, ash mantle over loose unconsolidated lapilli (McKelvey, 1963).

Soils are classified as podsolised yellow-brown pumice soils with low nutrient status and weakly developed structure (Leathwick 1981). The soils are of the Tihoi series, which, typical of airfall teohra, may be over two metres deep (O'Loughlin, 1978; MOW, 1975).

Topography, within the reserve, is undulating to rolling with altitudes ranging from 585 to 700 metres. Slopes are slight to medium and the land is dissected by steep sided streams, including the headwaters of the Waimiha, Whareana and Mangatahae rivers.

2.3 Climate

In the Pureora region the winter period (May to November) is the coldest and wettest.

July is the coldest month, with a mean normal temperature of 5.2°C, and February is the warmest month with a mean normal temperature of 15.6°C. The average annual precipitation is 1829mm (Leathwick, 1981).

Frosts are not uncommon due to frequent clear skies causing large diurnal temperature fluctuations; these frosts may occur in any month of the year (McKelvey, 1963).

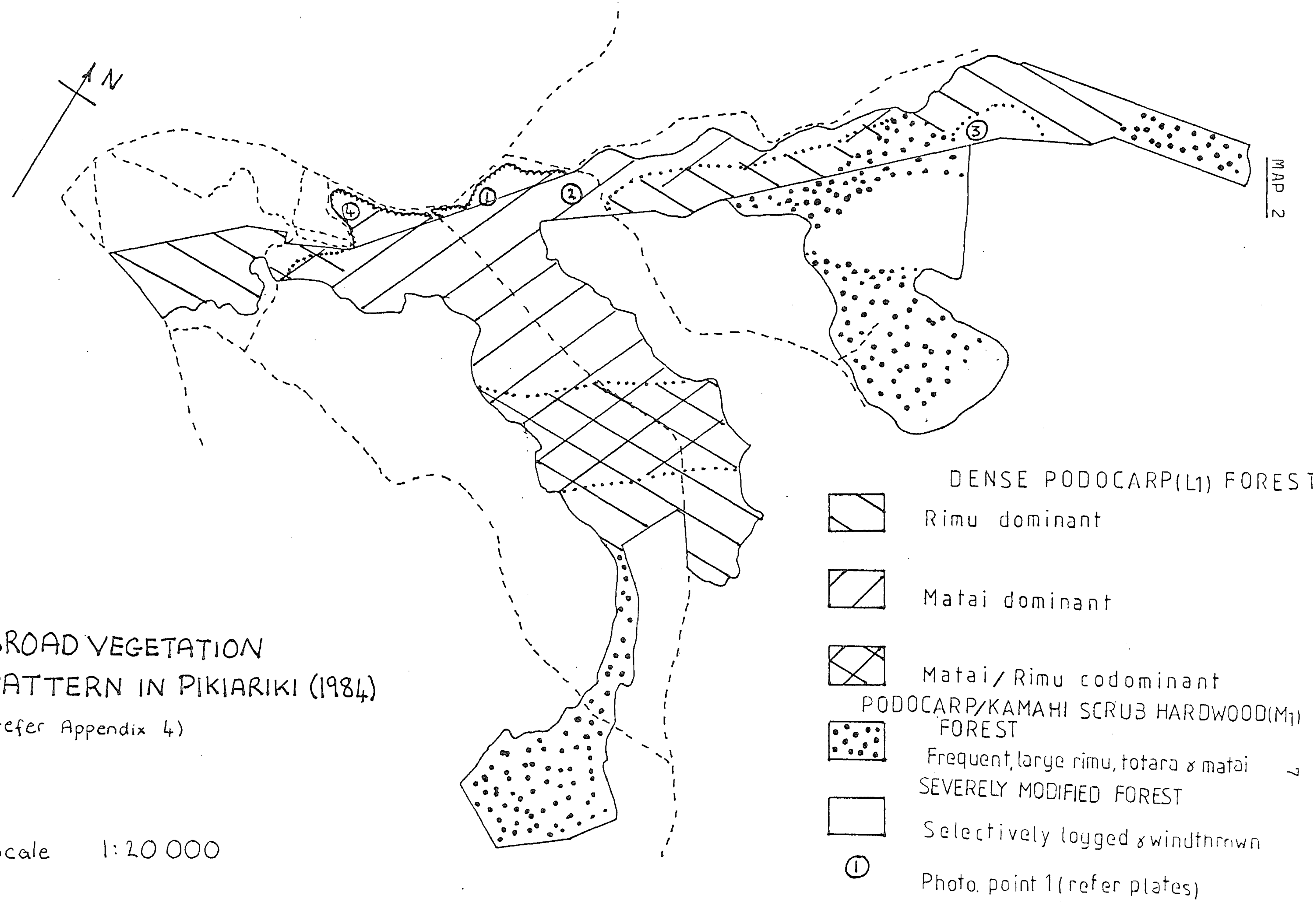
2.4 Vegetation (see Appendix 3)

Pikiariki is an example of, once extensive, lowland podocarp and podocarp-hardwood forests. Originally the area reserved was to be based on the extent of the ecological forest type L_1 (dense mixed podocarp), however inspections from the ground showed that the area indicated by McKelvey (1963) as L_1 forest was actually a mosaic of L_1, M_1 (podocarp/kamahi/scrub hardwood) and

M_2 (podocarp/tawa) characterised forest types (McPherson,1973). An area of M_1 forest was included in the ecological area as the Water Area and the Education Area is also M_1 forest (McKelvey,1963; McPherson,1973; Robinson,1976; NFAC,1977).

The pattern evident in this basically, L_1 forest is shown in Map 2. *Podocarpus spicatus* (Matai) is the dominant podocarp with frequent *Podocarpus totara* (totara), *Podocarpus ferrugineus* (Miro) and *Podocarpus dacrydioides* (kahikatea). This association forms the canopy along the northern boundary from Pureora Headquarters to near the eastern tip. Within this forest *Dacrydium cupressinum* (rimu) is rare or absent but becomes more frequent and finally dominant towards the southern end of Perham's Avenue. A single stand of dense totara on the northern side of Perham's Avenue and adjacent to Ngaherenga Camping Area is a local variation to the above (See Plate 2).

Plate 1: Dense tawa ~~poles~~ stand among matai (photo point 2).



BROAD VEGETATION PATTERN IN PIKIARIKI (1984)

(refer Appendix 4)

Scale 1:20 000

Dense
Plate 2: Stand of ~~dense~~ totara
(photo point 1).

Beilschmiedia tawa (tawa) is poorly represented within the dense podocarp forest of the northern boundary. It becomes more frequent towards the southern end of Perham's Avenue and in the north-eastern strip. Just to the south of Pikiariki Road there is a dense stand of tawa under a matai canopy. (Map 2). This is another variation within the general pattern.

Plate 3: Bad wind damage with the development of exotic weeds (photo point 3)

Modification has occurred in substantial areas of Pikiariki (ecological area and attached forest) (Map 2). Selection logging of the Education Area has removed approximately 30% of the podocarp component, this comprised 58% rimu, 25% matai, 16% Kahikatea and 1% totara (NFAC,1977; Harrison & Saunders,1981).

Strong winds during Easter 1982 caused considerable windthrow within these selectively logged areas and also in a small part of Pikiariki Ecological Area. In total, 138 podocarps were windthrown. Of these there were 109 matai, 16 rimu, 4 miro, 4 totara and 5 kahikatea. The remainder of the reserve suffered only minor windthrow (Yanko,1982).

The Perham's Avenue area has also been modified, although only slightly. In 1953 a 'creaming' operation removed only the very 'best' trees, mostly matai and miro (NZFS,1977).

Plate 4: Tall podocarps at the forest margin
(photo point 4)

2.5 Animals

(i) Birdlife

The podocarp forest of Pikiariki, supports one of New Zealand's most diverse avifauna. The rich hetrogeneous forest provides niches for many indigenous and exotic birds. An unconfirmed species list compiled by J Innes (FRI Rotorua) follows.

Paradise Shelduck
N.Z. Falcon
* Californian Quail
N.I. Kaka
Yellow-crowned Parakeet
Shining Cuckoo
Long-tailed Cuckoo
Morepork
Kingfisher
N.I. Rifleman
* Hedge Sparrow
Whitehead
Grey Warbler
N.I. Fantail
Pied Tit
N.I. Robin
* Song Thrush
* Blackbird
Silvereye
Bellbird
Tui
* Yellowhammer
* Chaffinch
* Greenfinch
* Goldfinch
* Red Poll
* Myna
N.I. Kokako
* White-backed Magpie

* Exotic Species.

(ii) Mammals

There have been reports of Native Bat sightings however the soecies is unconfirmed. The only other mammals within the area are:

Ship rat
Mouse
Stoat
Weasel
Ferret
Red deer
Possum
Hedgehogs

Pigs were once present, and domestic or feral cats may be present within the reserve.

3. HISTORICAL BACKGROUND

Early in Maori history, New Zealand's extensive podocarp forests seasonally attracted pigeons with their fruit. The pigeons were a valued food source for the people of the Tainui canoe who protected their territory from intruders (Phillips, source unknown).

Two Maori brothers, Maniapoto and Matakore, established a village for bird snaring at Tuturawhakamate, near Pureora. The best hunting in this area was to be found in a giant miro called Pikiariki. The tree was shared between the two brothers; the west branch to Maniapoto and the east to Matakore (Phillips, source unknown).

The descendents of Maniapoto and Matakore lived in and defended these territories for many generations before the arrival of the European (Phillips, source unknown).

By the 1920s Europeans had become well established in the King Country. In their quest for farmland and timber much forest was cleared. Those with foresight saw a timber shortage as inevitable; so in 1925 a 2½% reconnaissance survey was made of the Pureora Forest area. It was found that large timber volumes existed and so it was that Pureora Permanent State Forest was established in 1925 (Author and source unknown).

Logging began in Hurakia in the late 1920s and in 1939 commenced in Pureora. It was to help alleviate a national timber shortage and provide employment opportunities (Field & Robinson, 1978).

Logging continued into the 1960s and in 1968 and 1970 two long term sales of fifteen years were made by the New Zealand Forest Service (NZFS). These committed a total of 56 279m^3 of indigenous timber per year; largely to be supplied to local sawmills (Field & Robinson, 1978).

The 1970s saw the emergence of a more environmentally aware public and vocal conservation groups. Prompted by interest in forest wildlife, the Forest Service began to look at reservation of areas for ecological study (Field & Robinson,1978). In 1971 at the request of the Forest Service, the Wildlife Service conducted a survey in the remaining West Taupo forests. Details concerning the diversity and distribution of native birds were recorded with particular attention paid to the kokako (Crook et al, 1971; 1972).

Under the new Forest Amendment Act 1973, the Forest Service set about to retain "...a virgin strip along the northern and western boundaries" of the Pikiariki Block (McPherson, 1973). This area was noted for its good kokako population, its scenic value from State Highway 30 and its inclusion of a rather unique ecotone (McPherson,1973).

In considering the area for reservation, the Forest Service realised that some kokako habitat would be lost but timber from these areas was needed to fulfil legal contracts (McPherson,1973). Pleas from the

Royal Forest and Bird Society in 1974 and again from the Wildlife Service in 1976 to have larger areas of Pikiariki reserved were met by a compromise. The Forest Service had over estimated merchantable volumes and had lost timber to reserves and selection logging; greater areas of Pikiariki reserved would just compound the supply deficit they already faced (Miers,1971; McPherson,1973).

Clearfelling began in the Pikiariki Road Block in 1974. The 1977 Indigenous Forest Policy (NZIFP) saw a change in indigenous logging philosophy and felling operations were changed to selection logging. Among conservationists there was still much concern over the destruction of Pikiariki's forest and wildlife. During 1977, the Native Forest Action Council called for the ceasing of all logging operations in Pikiariki and Waipapa. Logging continued and in Pikiariki a confrontation developed between loggers and conservationists after protesters had climbed trees and refused to move from their platforms. As a result of the danger to life and the publicity that developed from this situation all logging ceased on 24 January 1978 (Leathwick,1981).

In 1978 a seminar was held to discuss points on management which had emerged since the confrontation. Papers were heard and submissions were received from the public. As a result, a policy statement was released by the Minister of Forests in 1978 setting guidelines which: (NZFS,1978)

(i) Cut supply of native timber from West Taupo Forests from 60 000m^3/year to 6 000 m^3/year.

(ii) Ceased logging in the North Block for three years.

(iii) Called for the undertaking of research on kokako.

(iv) Stated that at the end of the moratorium period the recommencement, or otherwise, of logging would not depend solely upon kokako habitat requirements.

So began the three year kokako study by a combined Royal Forest and Bird, Wildlife Service and Forest Service research group - the Forest Bird Research Group (FBRG). Its findings were included in three reports which suggested that logging should not recommence. It did not.

Remaining from what was the Pikiariki Block is Pikiariki Ecological Area; gazetted as such in 1979 (Appendix 2) and totalling 457 hectares. Attached to this is 90 hectares of selectively logged forest given respite as a result of the 1978 protest action. This became known as the Education Area.

4. RATIONALE FOR RESERVATION

A. VALUES IN RESERVATION

4.1 Introduction

Before the arrival of man, New Zealand was a land clad in forest. Since his arrival this forest, much of it considered a hinderance, has been reduced to only a fraction of its original extent (Thompson & Nichols,1973). Forest clearing has not been uniform over all the lands, however. Areas of lowland podocarp forest have suffered very heavily; these areas yielding prime farmland and offering valuable timber. The conversion of these forests has resulted in dramatic ecosystem alterations and partly as a consequence many indigenous bird species have become, or are near extinction. Of those that remain, the more habitat selective species have become restricted to small forest remnants.

The people of New Zealand are now much more environmentally aware, and active conservation groups seek for the protection of these few remaining forest areas. The value of these remnants as refuges for some of our endangered wildlife and for their own uniqueness is now being realised. Measures to preserve such representatives, for posterity, are considered as an integral part of wise land management.

One such tract of lowland podocarp forest is included in Pureora Forest Park, and within this is

Pikiariki Ecological Area. It remains as a representative of a once extensive dense podocarp forest. Its values and limitations will be discussed in this section.

4.2 Wildlife

Forest management has recently been faced with the necessity for the reservation of wildlife habitats. The aim being to end an abhorrent history of species extinctions (NFAC,1977; Williams & Given,1981). A limited knowledge of the biology of many forest birds has, however, made effective conservation difficult. To identify priority areas for reservation a form of valuation is useful. Such a valuation system should include factors "..related to the habitat itself (eg. its uniqueness on a regional, national, international scale), its biological composition (eg. species diversity) and each single species (eg. distribution, abundance, occurrance outside the region and country).." (Imboden,1978).

The results of a Wildlife Service survey of the West Taupo region, during 1970 to 1971, were interpreted in just such a manner. The system chosen comprised three wildlife value classes (outstanding, high, moderate (see Appendix 7)), with these equating, to some degree, with areas of international, national or regional importance (Imboden,1978). Two areas of the West Taupo forests were described as being of ' outstanding wildlife value' under this system. These being the

Ranganui and Pikiariki Road areas (Crook _et al_,1971; 1972). The extraordinary wildlife features described within these areas include; the presence of a good population of kokako and a general abundance of all indigenous forest birds, including kaka and parakeets (Crook _et al_ 1971; 1972; Imboden,1978).

(i) Kokako

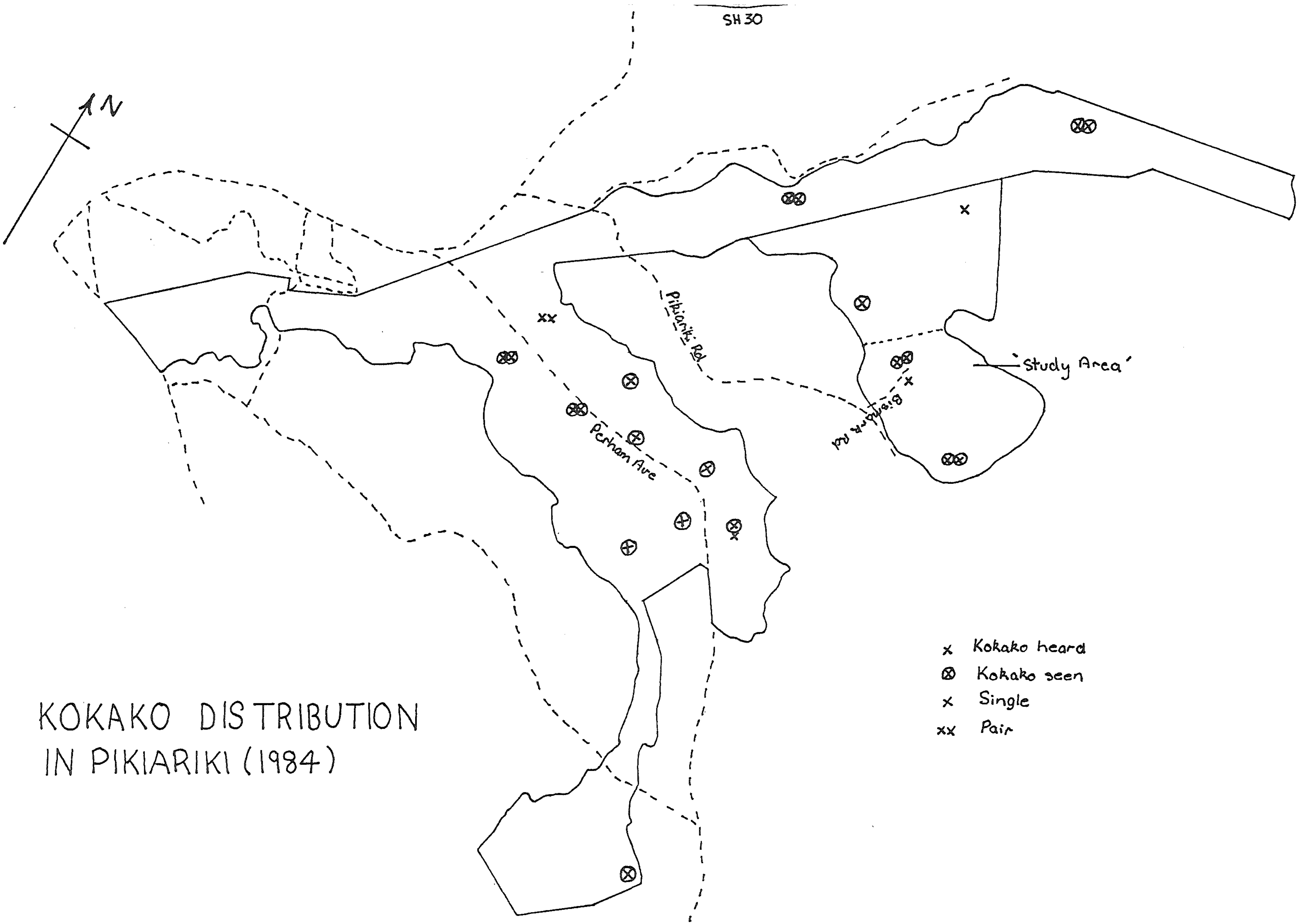
Plate 5

Kokako nest at Mapara (Photograph by J Leathwick)

The kokako (*Callaeas cineria*) is one of New Zealand's most ancient vertebrate animals; its ancestors became isolated in New Zealand at the break up of Gondwanaland (Hay,1984). It belongs to the endemic family of wattlebirds (*Callaeatidae*), along with the huia (*Heteralocha acutirostris*), and the saddleback (*Philesturnus carunculatus*) (Imboden 1978; Hay,1984). The North Island kokako (*C. cineria wilsoni*) is, however, the only member of this family that survives on the mainland. The huia is extinct, the South Island kokako (*C. cineria cineria*) is considered to be extinct or close to extinction and the saddleback survives only on several offshore islands (Imboden,1978;Hay,1981,1984).

The habitat range of the North Island kokako has shrunk considerably since the arrival of the European and although recent reports of kokako sightings are relatively widespread (Appendix 8), many of these are only very small populations (Hay,1981). The kokako is classified in The Red Data Book Of New Zealand as 'vulnerable', and its total numbers are estimated at being "..at least a few hundreds..." (Williams & Given, 1981).

Good populations, of kokako, however, exist in the Rotorua and West Taupo regions, with the dense podocarp forest type (L1) of Ranginui and Pikiariki Rd areas known to support dense populations (Crook *et al*, 1971; 1972; Imboden, 1978). It is in the larger tracts of kokako habitat, of Pureora and Rotorua, that hope for the survival of kokako must rest. Some doubt as to



MAP 3

KOKAKO DISTRIBUTION IN PIKIARIKI (1984)

Scale 1:20 000

their survival in the smaller isolated and modified pockets of forest has been voiced (Hay,1981).

An estimate of the number of kokako, in Pikiariki was obtained using a bird mapping method. The method and some of its limitations are described in Appendix 9. The picture of kokako distribution and density obtained will serve a useful purpose for management and, if need be, may be refined with more intensive territory mapping exercises.

In total twenty-five birds were located; this number being made up of eight pairs and nine single birds. Their approximate location, on the day of survey, is shown on Map 3.

It appears that the birds are concentrated in the more extensive, flatter, L1 forest area around Perhams Avenue and the M1 forest of the 'Study Area,' which may now have settled at its carrying capacity of two pairs. The decline in kokako numbers in this Study Area, since 1978, may well represent such a settling period after the logging of surrounding forest in 1977 and 1978. This trend is indicated in Table 1. The effect of predators however, must not be ruled out as contributing to this trend.

Table 1 Kokako Numbers in The Study Area (1978 to 1984) (Innes, pers comm, 1984)

Year of Observation	Pairs	Singles
1978 to 1980/81 (summer)	4	1
1981/82 (summer)	4	1
1982/83 (summer)	3	-
early Jan/1984 (Murphy)	2	1
late Jan/1984	2	-

Much of the rest of the reserve is uninhabited by kokako, being unsuitable because of heavily disturbed forest, steep terrain and because these areas are isolated, narrow strips.

(ii) Other Birdlife

The Wildlife Service noted the Pureora region as being significant because of the diversity of indigenous birds supported (Crook et al, 1971). Among these birds the North Island kaka (*Nestor meridionalis septentrionalis*), red crowned parakeet (*Cyanoramphus novaezelandiae*), yellow crowned parakeet (*C. auriceps*), New Zealand falcon (*Falcon novaeseelandiae*) and North Island robin (*Petroica australis longipes*) deserve special mention. All of these birds have suffered a significant decline in number and distribution since European settlement, although the robin has successfully settled in exotic forests (Imboden, 1978). All of these birds have been recorded as present within Pikiariki (Crook et al, 1971; Imboden, 1978).

As for the Kokako, the dense podocarp forest of Pikiariki and Ranganui Road areas support some of the most dense populations of both kaka and parakeets

(Crook *et al*, 1971; Imboden,1978). These birds are wide ranging in their search for seasonally abundant foods, including: fruit, berries, seeds, nectar and insects. This, in conjunction with their hole nesting habit, indicates the importance of old standing dead trees to these three parrot species and, in part, explains why they occur only in the larger tracts of less modified indigenous forest (Imboden,1978). Appendix 8 shows the distribution of these birds in the North Island and indicateshow sparsely distributed parakeets are.

Throughout Pikiariki, one may hear or see kaka, and parakeets are not infrequently encountered. Robins occur throughout the forest area and a pair of falcon nested in the Education Area during the summer of 1983 to 1984.

The presence of a good population of kokako in Pikiariki must, for the reasons discussed, rank as the primary value for reservation. The total value is, however, significantly increased by the diverse avi-fauna which also inhabit the forest, including: kaka, parakeets, falcon and robin. Such is the wildlife value of Pikiariki that it has been suggested, along with Ranganui, as a suitable Biosphere Reserve in the worldwide UNESCO Programme (Imboden,1978).

4.3 Vegetation

The Maori arrived in New Zealand to find a land whose area was 80% covered in forest. With burning, largely for cultivation, this was reduced to 60% by the time Europeans first arrived. The European has since reduced the forested area to around 23% of land area, and much of this reduction has been in the lowland forests (Environmental Council,1979).

It was largely because of the superior farmland and timber gained from clearing these lowland forests that they were so disproportionately affected. It is believed that lowland podocarp forest once grew to within one or two miles of Lake Taupo but, as a result of Maori burning,forest has been pushed well back from the lake (McKelvey,1963). West Taupo podocarp forests, however, still remained as one of the largest tracts of mixed podocarp forest in the North Island. At the time of the second World War this forest stretched from Tongariro in the south, to Mangakino in the north (N.F.A.C.,1977). Since this time large areas have been logged; the remnant virgin forest area being only 17% of that which existed prior to 1940 (N.F.A.C.,1977).

Little of what remains now is of the Dense Podocarp Forest Type which once surrounded the shores of Lake Taupo. Pikiariki stands as one of the few remnants of this forest type. Its L1 forest represents a far larger area of similar forest which was for hundreds of years colonising the poorly drained alluvial pumice lands between the Hauhungaroa and Rangitoto Ranges

(McKelvey,1963).

Much of the value of these forests is in their diversity. They comprise upwards of two hundred vascular plant species which are organised into a complex, multi-tiered, forest structure. Some of the largest podocarps in New Zealand, often in excess of two metres in girth (in M_1 & M_2 forest), support multitudes of epiphytes and lianes (N.F.A.C.,1977). The diversity in vegetation is well reflected in animal diversity; as one of the countries most impressive conglomerations of bird species inhabit these forests. Crook et al (1972) describe how L_1 forest of the Rangi-nui Road and Pikiariki Road areas support the highest density of kokako and their 1971 report shows kaka and parakeets to follow a similar pattern.

Plate 6: A large totara on NZ Forest Products land near Pureora; the sort of tree that was once in Pikiariki

Plate 7: Ecotone, showing stages of development; monoao nurse, sappling, pole and finally mature podocarps of Pikiariki.

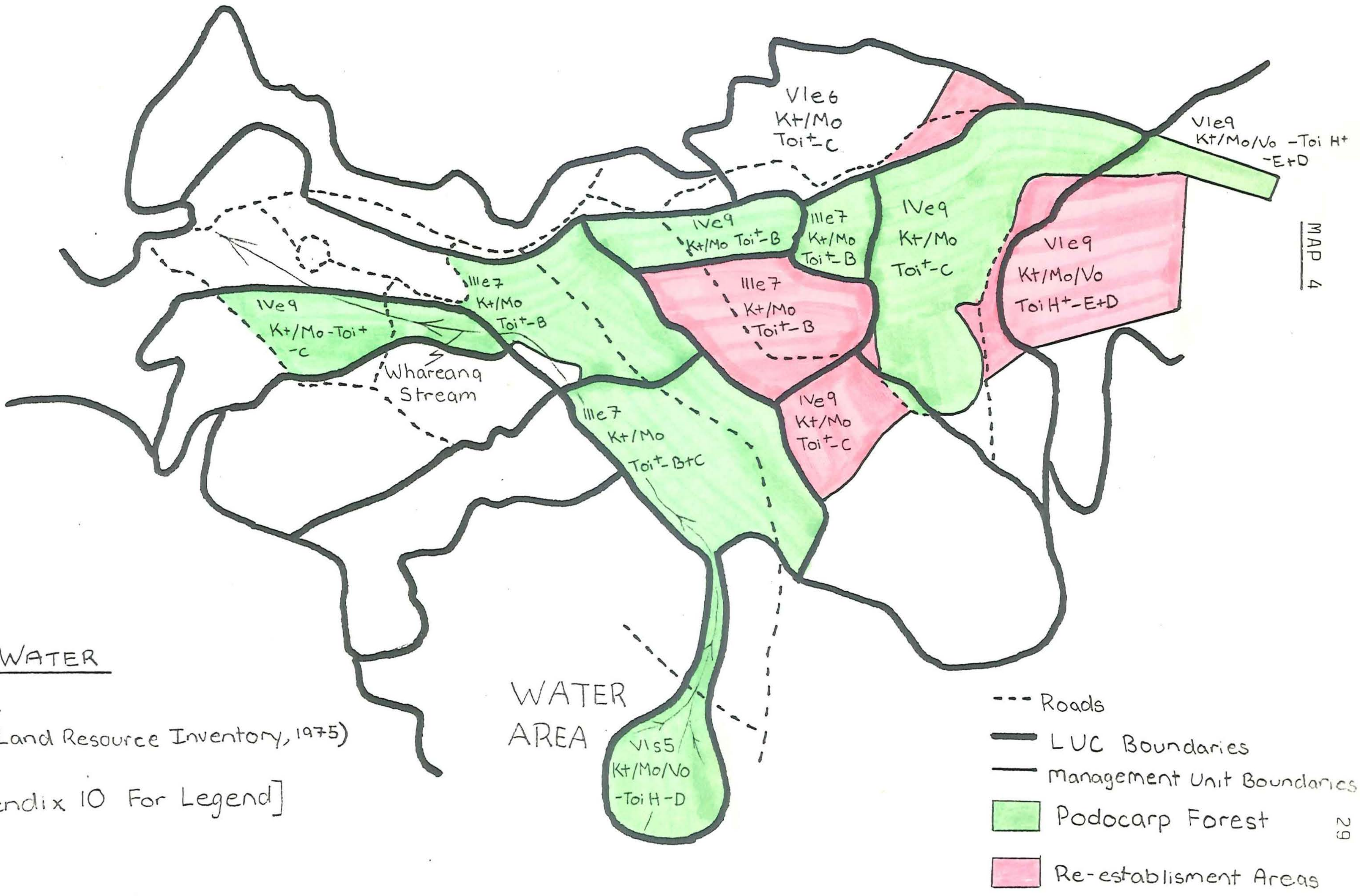
Fringing the reserve are small ecotone strips which are important examples of this successional stage. Within this ecotone seedling recruitment is still occurring, and it contains advance growth of matai and tanekaha (*Phyllocladus trichomanoides*). The extent of these ecotone strips is limited by man-induced boundaries (roads, farmland, exotic forest), however, and the intrusion of exotic weeds, including *Pinus contorta*, are detrimental to their integrity. Management to maintain these ecotones can not hope to exclude exotic weed infestations.

The West Taupo forests are one of the few areas where the root parasite *Dactylanthus taylorii* is still found. This plant has been much sought after by collectors for its 'wood rose' like appearance, after treatment. In conjunction with this removal, extensive podocarp forest clearing has resulted in this plant species being listed in The Red Data Book of New Zealand as vulnerable (Williams & Given,1981). *Dactylanthus* occurs within Pikiariki mainly in the ecotones and adds to the overall value of the reserve.

4.4 Soil and Water Protection

Two headwater streams of the Wanganui River, the Waimiha and Whareana streams, and one of the Waikato River, the Mangatahae Stream, originate from or flow through Pikiariki. A mantle of Taupo airfall tephra, often deeper than one metre, has formed a reasonably stable yellow-brown pumice soil and indigenous or exotic forest effectively protect this soil from sheet, hill and gully erosion. Soil erosion and high sediment loading of streams are most likely following land clearing operations, as excessive soil disturbance and poor track siting render these soils erosion prone (O'Loughlin,1978; MOW,1975).

In general the reserve plays only a minor role in soil and water conservation, because the Mangatahae and Waimiha streams pass through exotic forest and large expanses of farmland downstream of Pikiariki. In these areas forest and pasture management pose a more significant threat to water quality. Periodic land



SOIL & WATER MAP

(From - MOW Land Resource Inventory, 1975)

[See Appendix 10 For Legend]

MAP 4

clearing in exotic forests and phosphate and potash fertilisers used on farmland will largely negate any water quality that Pikiariki imparts (O'Loughlin,1978).

The area marked on map 4 as the Water Area does, however, play an important water protection role. The Whareana Stream flows through this area, it is the source of drinking water for the Pureora Village. Purity and volume of water yielded are important attributes. The MOW Land Resource Inventory Legend (1975) describes this area as "..strongly rolling - moderately steep; stable hills with a deep mantle of Taupo airfall tephra over older tephra. Potential for slight sheet erosion." (Map 4).

Past management has recognised the importance of the Water Area and the value of the Whareana Stream as a domestic water source. Early on, it was decided that the area should be left with its virgin forest cover as an addition to Pikiariki Ecological Area. It was stated that any logging of areas through which sidestreams passed, before entering the Water Area, should ensure that the waterways did not become contaminated with cutover bush and silt (McPherson, 1973).

Plate 8: Pureora Village water reservoir

4.5 Recreation

Forest recreation has, since the 1976 Forest Amendment Act, been recognised as an integral part of balanced land use for State forests. In the broader sense the term recreation describes the recreational, educational, historical, cultural, scenic, aesthetic and amenity functions of forests. (1976 Forest Amendment). The NZIFP (1977),* however, states that "..the preservation of the natural resource must be the first and paramount consideration."

* NZ Indigenous Forest Policy (NZFS,1977)

Pikiariki Ecological Area must be recognised as an area for the preservation of the natural resource and this will thus preclude intensive recreational use. Recreation is,however, an important secondary value within Pikiariki, with a small but significant pressure placed on the area by a specific section of the recreating public. Pikiariki offers easy access for the passive, or specialist recreationist, being traversed by four forest roads and skirted by several more. State Highway 30, from Bennydale to Mangakino, services the Pureora region providing access from surrounding population centres of the Waikato, Bay of Plenty and the Auckland urban areas (Dale & Fleming,1978).

The number of recreational users is, however, limited by relatively long travelling distances and by competition for the public of the urban areas, from the Waitakere, Hunua and Pirongia Forests (Dale & Fleming, 1978). Dale and Fleming (1978) consider that people would possibly travel to the Pureora region for extended periods of camping, for tramping and hunting and for special purpose trips, for example bird observation, where the facilities for these activities are provided.

Important factors affecting the recreational pressure placed on Pikiariki include; the close proximity of the Pureora Village, the Forest Headquarters, the information centre, the Ngaherenga camping ground and the Pureora Education Camp. Pikiariki is visible from SH30 and is often the first forest to be seen on entering Pureora Forest Park. It may be described as a 'window' to Pureora.

Over the summer of 1983/1984 a 'summer programme' was conducted from Pureora Headquarters. The programme had only a moderate attendance (147) but it showed the importance of overnight camping at Ngaherenga and that many of those that participated had an interest in Pureora's rich wildlife (Calder,1984). It would be fair to comment that an increase in visitors, to the park and Pikiariki, would result from increased publicity and the development of camping and wildlife observation facilities.

Limited recreational development of Pikiariki has an intangible value; it would remove most of the recreational pressure from relatively more important areas, such as Waipapa Ecological Area. Like Waipapa, Pikiariki offers superb vistas of some of the finest Podocarp forest and richest birdlife remaining in New Zealand. The viewing of kokako must rank as one of the prime reasons for visiting the park by bird enthusiasts. Within the Education Area, kokako may be observed from Bismark Road without harmful wandering through the bush and limited tracking (Totara track) on well drained soils allows the active recreationist to experience the inside of a forest without damaging vulnerable areas.

Considerable potential exists within Pikiariki for the development of educational values. The forest is represented by several successional stages, including the ecotone, and, along with its diverse avifauna, this provides an ideal situation for an 'outdoor classroom'. The gentle slopes and its limited extent would make for easy control of students whilst allowing relative freedom of movement (NFAC 1977). Furthermore, education in Podocarp high forest could be integrated in an agenda which looked at other aspects of forest management close at hand, including indigenous re-establishment and exotic afforestation. Other aspects of interest to visitors include the neighbouring 'Buried Forest' and the history of conservationist's protests, gleaned from an old platform remaining in a totara.

Many may derive a form of recreation from Pikiariki even though they never visit it. In the words of Fraser Darling, "A deep and widely pervading tide of human thought wishes there to be wild places, even though many people will never visit them. There is satisfaction and comfort merely knowing they exist." (in Env. Council, 1979).

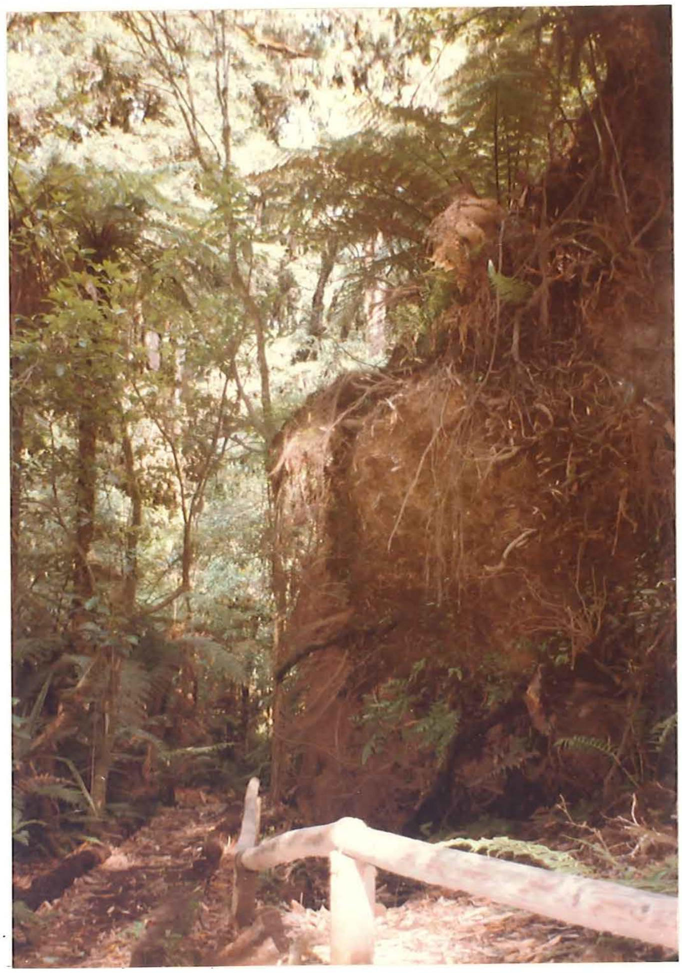


Plate 9: The large rootplate of a windthrown rimu near the Totara Track; descriptions of such natural and man-induced events should be an important aspect of recreational development.

4.6 Science

Pikiariki has, in the last decade, been the centre of much scientific research. Particular attention has been paid to its kokako and their protection by predator control. Revegetation trials in and around the reserve also provide valuable information.

Apart from the preservation of wildlife, management will provide valuable information concerning ecological area management. This is a new aspect of forestry in New Zealand. A lack of knowledge of our forest ecosystems and of the likely effect of various management regimes on them has precluded most interference, although it is often needed. For example, it is well recognised that possum control is essential in kokako habitat, however uncertainty concerning the effect of 1080 poison and other control measures on rare birds, like the kokako and kaka, has meant that foresters have shyed away from such measures. Pikiariki provides an outdoor laboratory where sensible ecosystem manipulation may be developed to protect wildlife.

Furthermore, modified as it is, Pikiariki is a unique forest representative. It provides a baseline from which to measure changes occurring on surrounding farm and exotic forest land. Over time, information concerning the dynamic and successional nature of these forests will be important in the understanding of our forests and will give clues concerning land management.

It will be interesting to compare the ecology of Pikiariki with that of the 1800 year old 'buried forest' alongside. Differences, or similarities, in composition will give information concerning the successional theories of West Taupo's forests.

Science must not only consider what is here now but must recognise that changes in knowledge and technology may, in the future, require that new facets of these forests be investigated. We must thus protect representative ecosystems for the sake of future generations, whose needs we are unsure of.

8. CRITERIA FOR RESERVATION

The outstanding wildlife and other values of Pikiariki have been discussed in the previous section. The true or long term value of these components may, however, only be realised if, in reservation, factors concerning the biology of a species and its interactions with other natural forces are accounted for. It is not enough to say that because a given habitat contains a high density of a valued species,only this area need be reserved while surrounding, less favourable, habitat may be cleared. The reduction in species, often valuable species, that results is likely to be significantly greater than the expected disappearance of 'merely' a few individuals in the cleared, less preferred, habitat. Thus for effective conservation the reservation of maximum rather than theoretical minimum areas of habitat is necessary. The knowledge we have of our natural systems is relatively little, as such the reservation of areas for the conservation of these ecosystems must err towards larger reserves.

The question thus arises; on what basis was Pikiariki reserved and is it of such a size and nature that its values may be maintained?

Under the Forests Amendment Act 1973, areas, not to be set aside as 'sanctuaries,' that are to be used for scientific or educational purposes or for the protection of flora and fauna may be zoned and dedicated for these purposes. The Forest Amendment Act 1976 emphasised the importance of dedicating such Ecological

Areas; in accord with its balanced use, protection production and recreation policy (NZFS,1983).

The 1977 Indigenous Forest Policy states that the aim of such reservation is to:

(i) understand and explain natural processes

(ii) maintain bench-marks for measuring change on initially comparable land

(iii) maintain genetic diversity of plants and animals

(iv) preserve rare plants, native fauna, archaeological or other historic sites, particular topographical features and geological and soil sites.

The Scientific Co-ordinating Committee, with the aim of satisfying the above needs, defined a set of guidelines on the nature of suitable reserves (Basset, 1977; NZFS,1983):

(1) Ecological areas should represent the full range of land-forms, soil sequences, animal communities, and unmodified vegetation of the ecological district. The inclusion of some modified vegetation may sometimes add to the value of the ecological area.

(2) A single large reserve in excess of 1000 hectares is preferable to several smaller reserves of the equivalent combined area. This is particularly true for preserving the greatest diversity of bird populations.

(3) It is considered legitimate to create small reserves to preserve unique features or special values, although these could present special problems in protection.

(4) Each representative ecological area should include at least one complete undisturbed catchment of a permanent waterway.

(5) It should have a compact shape, with the minimum perimeter for the area involved.

(6) Wherever possible, the boundaries should be clearly defined by natural features.

(7) It should be unroaded, at least within the main catchment.

Areas dedicated may not necessarily satisfy all of these criteria and in most cases will not stand alone as 'islands', but are 'embedded' in large tracts of surrounding forest that is zoned for other compatible uses (B.L.Geden pers comm,1983). Furthermore, reserves in state forest should not be considered in isolation. The scientific values of indigenous forest in national parks, scenic reserves or unoccupied Crown land should be taken into consideration (NZFS,1977). This concept is embraced by 'Ecological Districts' approach to reservation now being adopted by the NZFS (NZFS,1983).

The values inherent in Pikiariki have been discussed. The need for the reservation of a forest area to protect these values was recognised by the Forest Service and an area of 105 hectares, representing the extent of the most favourable kokako habitat (L_1 forest type) was, in 1973, to be reserved (McPherson 1973). After requests by the Wildlife Serve and conservation groups this area was increased to 388 hectares of predominantly L_1 and some M_1 forest (Conway,1976). This was to be set aside as an 'amenity area' (Dale, 1976). Later the Scientific Co-ordinating Committee (SCC), in recognition of the forest's high scientific value, recommended that 457 hectares of Pikiariki be reserved as an 'ecological area'.

Pikiariki (ecological area and adjoining indigenous forest) appears, however, to comply with few of the guidelines for reservation set by the SCC. Its present area has arisen from a series of compromises between protection and production objectives. The demarcation of a reserve, for kokako conservation, on the basis of the single successional (L_1) forest type has not adequately taken into consideration the biological requirements of kokako, nor of other avifauna. As a result, there is likely to be considerable change within the forest ecosystem and the initial objectives for reservation are unlikely to be fully realised. The changes which may occur can be explained by applying the theory of Island Biogeography to Pikiariki.

The theory of Island Biogeography describes reserves of native forest as being like 'islands' to birds or other animals that rarely cross the 'seas' of pine plantations and farmland surrounding them (Fleming,1975). The implications of such biogeography, Diamond (1974) points out, are:

(1) The ultimate number of species that a natural reserve will save is likely to be an increasing function of the reserves area.

(2) The rate at which a soecies go extinct in a reserve is likely to be a decreasing function of the reserves area.

(3) The relation between reserved area and probability of a species survival is characteristically different for different species.

(4) Explicit suggestions can be made for the optimal geometric design of reserves.

Further to this, Diamond (1974) describes how the number of species in an 'island' decreases with distance from a source of colonisation, and for animals with weaker powers of dispersal, the fall-off in species number is even more rapid.

The longevity of a species depends on their continued immigration into the area while local extinctions occur. Long term survival will occur where an equilibrium is reached between these two forces. Due largely to population fluctuations, however, the smaller the island, the smaller is the population and the higher the extinction rate. Similarly, the more remote the 'island', the lower is the immigration rate, due to the dispersion of colonists (Diamond, 1974).

Hackwell and Dawson (1980) point out that area is the most important factor. The question then; is Pikiariki large enough to sustain the present diversity of bird species, and will kokako remain?

This problem may be tackled from two points of view (Diamond, 1974):

(1) The chance that a reserve where a species has gone extinct will be recolonised from another reserve.

(2) The chance that a species will go extinct in an isolated reserve.

The chance that a reserve will be recolonised depends on the isolating distance and the dispersal characteristics of the species. Flying bird species disperse better than those that can not fly, so the more sedentary the species the more irrevocable will be any local extinctions (Diamond,1978).

Poor powers of flight restrict kokako to their forest habitat and prevents them from long distance dispersal (Hay,1981). Recolonisation of Pikiariki, in the advent of kokako extinction is therefore unlikely.

Bird species with initially low numbers, due to very large territory requirements, and birds dependent on seasonally available food sources are especially prone to a decrease in habitat area. This is a description which fits the kokako well (Hay,1981).

The original kokako habitat range of the old Pikiariki Block has been reduced to around 550 hectares much of this being unsuitable or too 'elongate'. In such elongate or dead end peninsulas dispersal rates may be so low that local extinctions occur by island like effects (Diamond,1974). This area of 550 hectares thus compares less than favourably with the 1000 hectares recommended by the SCC as a minimum area for ecological areas. Hackwell and Dawson (1980) consider that kokako and parakeets will be lost from most forest patches of less than 2000 hectares. The local extinction of kokako and other bird species within Pikiariki would, it seems, appear to be likely and the probability of such extinctions is increased considerably by the presence of predators and browsing animals (Section 5).

Within Pikiariki one can expect a decline in bird species present over time, as an equilibrium level is reached. Diamond (1974) estimates that a tenfold decrease in area will result in approximately a twofold decrease in the number of species present. The great diversity of species now present in Pikiariki may well be temporary, their slow disappearance being characteristic of a 'relaxation' period. It is also likely that those that will vanish over the relaxation period will be those of greatest value; including kokako, kaka and parakeets.

Summary

Pikiariki is valuable because of the wildlife features within it, however, as a result of poor design, largely due to a lack of knowledge and pressure for timber production, it stands as a poor example of an ecological area. It is small in size, lacks a compact shape, is traversed by several roads and many of its boundaries are not based on permanent natural features. As a result, the primary values for which the reserve was designed to protect are unlikely to survive without considerable management intervention.

5. RATIONALE FOR MANAGEMENT & OBJECTIVES OF MANAGEMENT

5.1 Introduction

Devastating events, of varying magnitude, have been prominant in the natural history of New Zealand. As recent as 1800 years ago extensive areas of forest, surrounding Lake Taupo, were destroyed by a volcanic eruption. On a smaller scale; wind blows and fires, started by lightening strikes, helped to shape the nature of forest cover that the Maori encountered on his arrival. These devastating events may have caused local population extinctions but neighbouring forest would provide a source from which colonists could re-infest the regenerating forest.

The arrival of man has resulted in catastrophic forest clearing, beyond compare in New Zealand's history. No longer can we be certain that local population extinctions, due to fire, wind or man's introduced animals, can be replaced by colonists. In this situation local population extinctions may result in species extinctions.

Pikiariki is faced with a similar situation. It is, as are most areas in New Zealand, prone to the devastation that would be wrought by a volcanic eruption, or earthquake. Of more immediate importance, however, is the threat that more localised, man induced, pressures pose to its valuable wildlife. The primary threats to the existence of kokako and other wildlife in Pikiariki are discussed in this section.

5.2 Damage To The Forest Environment

The forest environment is like an 'island' to those birds that inhabit it (Diamond,1974). If you remove the island these birds will be left to 'drown' in the 'sea'. Such is the situation which potentially poses the greatest threat to the kokako. If past habitat destruction does not ultimately bring its extinction then any future clearing is sure to. It is ironical that man, who values diversity in birdlife, is still potentially the greatest destroyer of this value. In the case of Pikiariki, however, reservation has removed the danger of deliberate habitat destruction and now accidental or environmental disturbances are the greatest threats.

5.2.1 Fire

Fire may be both a threat to, or a tool used by man. To Pikiariki fires only represent the danger of major forest depletion. Periodic dry spells and evidence of past Maori burning show these indigenous forests to be flammable (McKelvey,1963). The sight of a lightening strike on a large moribund totara is not uncommon and such trees may burn for days, dispersing ash and embers for some distance.

Man's manipulation of fire, to cook on campfires or to clear cut-over land, threatens forests when such fires are not adequately attended to or if they get out of control.

The danger to Pikiariki is considerable. Frequent lightening storms, adjacent 'burn-offs', and campers may easily be the source of a fire which would destroy all or part of the forest. If the forest is lost, then so too are all other values.

5.2.2 Wind

Pureora is an exposed site, and history has shown that windstorms periodically wreck havoc in its podocarp forests. An elderly Maori told of a severe storm which, in the early twentieth century, swept the forest and uprooted hundreds of trees. More recently, the Easter 1982 windstorm blew over trees in selectively logged and other windprone parts of the forest (Section 2.4).

Plate 10: Tree ferns and herbacious weeds proliferate in the mess left after windthrow.

Vulnerability to wind is related to the nature of the forest perimeter (ie. shape and abruptness), species, age, height and soils. Pikiariki has a boundary which presents a lengthy irregular, edge to winds; furthermore the logging of adjacent exotic forest will leave newly exposed cutting faces, which are vulnerable to wind damage. The formation of large canopy gaps by selection logging or windthrow may further induce wind damage.

Old moribund podocarps with large spreading crowns loaded with epiphytes and hollow rotting trunks, constitute an unstable structure which will, in time, blow over. Windthrow of this type is only of concern, however, where it is extensive and results in severe habitat depletion.

Pikiariki, then, appears to be vulnerable to wind destruction. The effects are, however, likely to be greatest in the outlying strips, severely modified areas, on soils where underlying hard pans occur, and where abrupt forest boundaries are created by logging. In this respect areas of kokako habitat are least vulnerable to damage, but the Water Area is at some risk.

5.2.3 Browsing Mammals

Over the years Pikiariki is known to have supported red deer, pigs and possums. Pigs are now only in low numbers (or absent) and the effect of the others, on the forest, has only been moderate (Leathwick,1981).

Currently possums appear to be exerting the greatest influence on vegetation. By preferentially browsing more palatable plants (eg. fuchsia, raukawa, and fivefinger) possums may alter the species composition of a forest. While the more palatable species become rare or extinct, those less palatable will proliferate (Leathwick, et al 1983). Selective browsing by possums in Westland's rata-kamahi forests is partially responsible for extensive areas of dead, and dying rata and kamahi (Stewart & Veblin, 1982).

The forests of Pureora are said to be some of the least altered by deer in New Zealand. This is largely due to Pureora being some distance from points of deer release (Leathwick, 1981). Deer probably did not reach the area until the 1950s and have never reached high densities (Leathwick, et al 1983). Leathwick (1981) attributes the maintenance of low deer numbers mainly to recreational and commercial hunting. Good road access and close proximity to Pureora village facilitates this control.

In many of New Zealand's indigenous forests irruptions in deer numbers has been responsible for severe forest depletion. These deer, because of selective browsing, often profoundly, alter the forest species composition (Leathwick et al, 1983).

It is in combination, however, that these animals pose the greatest threat. A reduction in the forest canopy in conjunction with depletion of the shrub layer will drastically change the forest structure. Further browsing of regeneration will prevent the replacement of dead and dying trees.

Left unchecked deer and possums can be expected to cause considerable alterations to the existing forest species composition and structure. This is of significance because it;

(1) alters a valuable podocarp forest remnant and its associated scientific, protection and recreation values

(2) and may leave the forest unsuitable for kokako habitation.

5.3 Depletion of Forest Wildlife

5.3.1 Predation

New Zealand's endemic bird species have evolved in the absence of mammalian predators. Many native birds are poorly adapted to the threat of recently introduced rodents and mustelids; those especially prone appear to be the endemic species including endangered species and subspecies.

Even as early as the 1870s Buller (in Atkinson, 1976) suggested that the ship rat (*Rattus rattus*) was in part responsible for the marked decline in numbers of species and abundance of endemic birds. In retrospect there is now evidence, if somewhat circumstantial, to link the decline of many of New Zealand's forest birds last century with the arrival of *R. rattus* (Atkinson, 1976). Recent examples such as the Big South Cape Island rat irruption with consequent extinction of endemic bird species, including the saddleback and robin, are illustrative of this (Bell,1976). St Paul and McKenzie (1974) attribute the dramatic decline of kokako in the Hunua Ranges to be almost entirely due to predators; the chief being the ship rat.

Another newly introduced group of bird predators is the mustelids, including stoats (*Mustela erminea*), weasels (*M.nivalis*) and ferrets (*M.patorius*). This group is also likely to have been prominent in the reduction of bird species; both stoats and weasels are efficient arboreal bird predators (Hay,1981).

Surveillance work by Moors (1976) in Kowhai Bush, near Kaikoura, has shown that predations, by rodents, on forest birds may be positively identified and that they are important predators on robin nests. Later work by Moors in the same area showed that mustelids preyed on 76% of observed nests (in Innes,1982).

The nesting period is when predation is likely to be greatest, with eggs and nestlings easy takings while adult birds tending nests may also be vulnerable. Such was the case on Big South Cape Island where the female saddleback population was depleted much more rapidly than the male; presumably due to greater vulnerability while nesting (Bell,1976).

What of the kokako? Studies have shown that kokako have existed for some time in areas where predators have been present for many years (Innes,1984). This is, however, misleading as kokako may live up to 25 years (Hay,1981;1984) and adult birds appear to be far less vulnerable to predation than their nestlings. Kokako nesting statistics over the three year study period indicate how vulnerable these nests are: In the three study areas five nests were found, of these three were preyed upon at the egg stage and two at the nestling stage (Innes,1982). The identity of the culprits is not known with certainty; however in all three areas, including Pikiariki, rats (*R. rattus*),mice (*Mus musculus*)and all three mustelids are present (Hay,1981).

Hay (1981) points out that large nest size, positioning of nests near major forks and the ejected fecal sacs of nestlings mean the probability of discovery is high. Furthermore, a long incubation and nesting period, of around fifty days, and the fact that rats visit most of their range each night increases the chance that any given nest will be preyed on (Innes,1984).

These factors are further confounded by population patterns of the predators (Section 6.3). Hay (1981) found that there were seasonal fluctuations in the numbers of rats and mice in Pikiariki study area. Numbers were found to be lowest in early summer but increased rapidly from late December to peak in Autumn (Section 6.3). It is also suggested that stoats enter the area at the same time (Innes,1982). Work by King (1983) in beech forest has shown that stoats respond to an increase in mice numbers both numerically and functionally and, because there are more stoats, predation on birds is likely to be greater in summers of mast beech seeding. This finding may be applicable to podocarp forest, however in these more complex forests any number of interacting factors may be involved (C M King, pers comm, 1984).

Summer peaks in predator population numbers corresponds with the nesting period of kokako, that is December and January (Innes, 1984). Once again, this considerably increases the probability of predation and decreases the likelihood of successful nesting.

Best (1969) and Daniel (1973) point out that in an area where the ship rat has been present for some time birds play a minor nutritive role. In the advent of an unusually heavy seed fall, however, a rapid build up in rat numbers (Section 6.3) may, after consumption of the seeds, result in a shift of attention to preying upon birds.

A further threat is imposed after windthrow. The vegetation and soil disturbance which results provides conditions in which mice and stoats tend to become more frequent. Similarly pine stands adjacent to Pikiariki are likely to support higher rabbit and mice numbers and perhaps pine seeding will have similar affects on mice and stoat population dynamics as in beech forests (C M King pers comm, 1984). If this did occur then there may well be increased predation on the neighbouring indigenous forest birds.

5.3.2 Competition

Some of the effects of deer and possums on the forest have been described (Section 5.2). To birds, especially endemic birds which are poorly adapted to mammalian competition, modification of forest will primarily have two consequences:

(1) It will result in spatial modification of a habitat.

(2) It may result in the depletion of essential food materials.

Other effects which upset the complex forest ecosystem will also be transmitted, to a varying extent.

The forest of the Hunua Ranges once supported a healthy population of kaka and parakeet. As a result of heavy browse by cattle, goats, pigs and possums the vegetation has since suffered depletion and neither kaka nor parakeet survive (NFAC,1977).

To the kokako forest modification by deer and possums poses a significant threat. Leathwick et al (1983) describe how, in the Urewera forests, present kokako distribution relates to the intensity of modification. Kokako tend to be in the more diverse, less modified forests of the region (Leathwick et al, 1983).

The kokako has poor powers of flight (Hay,1981) (Appendix 11) and, although they are aptly suited to movement within their natural habitat, their survival is uncertain where severe modification destroys spatial continuity within the forest.

Competition for food plants by deer and possums is yet another factor which appears to be limiting the survival of kokako (Leathwick *et al*, 1983). The feeding habits of the kokako are those of a sequential feeder. Work by Hay (1981) indicates that their dietary preferences change with food availability. Throughout the year variations in diet were recorded, with scale insects occupying up to 77% of their feeding time over the breeding season and fruit was consumed when it was available (mainly autumn). It appears that leaf material is used when other preferred species are not available (Hay,1981). Of the plant material featured in the diet, some appear to be more important than others for example pate, fivefinger, kaikamako, epiphytes and lianes (Hay,1981).

To the kokako the possum is immediately the greatest threat. The possum has a wide range of food preferences and an arboreal feeding habit. Its dietary preferences often overlap with those of the kokako and associated with possums is a reduction in the availability of preferred kokako foods, including; pate, five finger, raukawa, lancewood and various fruits (Leathwick, 1981; Leathwick *et al*, 1983). By concentrating its feeding on these most palatable species the possum may locally bring them to extinction (Leathwick,1981).

Deer also present a threat to kokako survival, although not as immediate. Associated with their presence is the reduction of large leaf coprosmas, five finger, pate and other palatable plant species (Leathwick *et al*, 1983).

As previously mentioned, the combined effect of deer and possums presents the greatest danger. Possums may initially deplete preferred kokako food while deer will, in the long term, prevent regeneration. Food may become so depleted that foraging costs birds more energy than is gained in eating and extinction will result.

5.3.3 Reproduction

The long term viability of birds within a habitat depends on their reproduction. If a population is unable to reproduce successfully then it will become extinct. Poor breeding success may be attributed to a number of factors, including inadequate nutrition, and predation.

Both of these aspects have been discussed, as they relate to the kokako (Section 5.3.1; 5.3.2). History has shown that these birds have had a poor breeding record: of twenty kokako nests observed between 1885 and 1982, five fledged successfully, nine were preyed on, one was plundered and five were deserted or their fate unknown (Innes,1982).

The impact of competition and predation is likely to be greater on a bird which has a low production potential, as does the kokako. This species has a maximum output of three young per pair per annum; however the actual output is only 0 to 0.2 fledged juveniles per pair per annum (Hay,1981). This low success, is most probably due to predation (Hay,1981). However, Leathwick (1981) indicates how nutritional deficiency may also be involved. Work done on the takahe illustrates how nutritional inadequacy contributes to reproductive failure (Leathwick,1981). Similarly, high protein foods such as the six-pennyscale insect are important to the kokako. If these insects become depleted then there will, more than likely, be a decline in the kokako's plane of nutrition and reproduction rates may decline (Leathwick,1981).

The six-pennyscale insect is chiefly found on the host plants; pate, broadleaf, five finger and horopito, which are all prone to heavy deer and possum browse (Leathwick,1981). Increased browse on these plants would reduce insect availability and, as a consequence, may have a detrimental effect on kokako reproduction.

In their favour, kokako have a long breeding life of up to twenty-five years (Hay,1984). Whether or not this is long enough to maintain a population is uncertain. At present Pikiariki has only low to moderate browse, and the preferred kokako foods are still abundant. Reproduction has not, however, been very successful. Over the three year 'study period' five nests were observed (one at Pureora); all of these were preyed on. After a wider search of Pureora only one juvenile per fifteen adult pairs, in 1979-80, and two per fifteen pairs, during 1980-81, were observed (Hay, 1984). This poor success rate must be attributed primarily to predation.

It appears that reproduction is being limited by predation; thus predator control should be a priority of management. In time a build up in browsing mammal numbers will also have a significant effect on breeding success. This situation can and should be prevented.

5.4 Balanced Use and Conflicts

Forest areas may have many demands upon them for their use. Section 4(1) of the 1976 Forests Amendment Act states that; all State forest land should be managed "...to ensure the balanced use of such land, having regard to the production of timber or other forest produce, the protection of the land and vegetation, water and soil management, the protection of indigenous flora and fauna, and recreational, educational, historical, cultural aesthetic, amenity and scientific purposes ."

These, however, are often conflicting and if compatible, they may only be so with constraints. In an ecological reserve timber production conflicts with the primary protection value. Recreation is generally compatible, but only at a scale at which it does not cause excessive disturbance of the ecosystem.

The problem arises when there is demand for all of these uses. One must identify the primary, or predominant use and then others which are compatible may be incorporated, possibly with constraints.

In Pikiariki kokako protection is of prime importance and will largely determine reserve management. Soil and water protection is a use which is compatible and is the predominant use in the Water Area. Recreational pressure has been identified as being small and specialised, but significant. It is a compatible use but with constraints; these being limitations on intensity, location and nature of use.

Management must cater for a range of uses but ensure that protected values are not sacrificed.

5.5 Objectives of Management

The values inherent in Pikiariki and faults concerning its nature have been discussed. Management must firstly ensure that those features of highest value are protected and then, if compatible, other features of secondary worth may be considered. On the basis that the kokako is the prime feature the following management objectives are recommended:

(1) The long term survival of kokako must be assured within Pikiariki. This should involve the lessening of predation and competition caused by introduced mammals, and if this is successful will necessitate the stabilisation of the reserve by indigenous re-vegetation.

(2) Other birdlife, notably kaka and parakeets, should be accorded high priority for protection and will generally be so protected by management to fulfill objective (1) above.

(3) Soil and water protection is important in the 'Water Area' and the prime objective of management in this area will be to maintain drinking water quality.

(4) Recreation and scientific use of the forest must not endanger the forest

wildlife, and will be compatible only where this danger is not high. Implementation of a recreation strategy must be such that impact on the forest ecosystem is minimal.

6. MANAGEMENT GUIDELINES

6.1 MANAGEMENT OF AN ECOLOGICAL AREA

The diversity in flora and fauna of our lowland podocarp forests is equalled by few other vegetation associations in New Zealand. They provide a natural ecosystem of such complexity that man can often only guess at their processes. It is little wonder that forest managers have shyed away from intervention management, the consequences of which they are unsure.

What is clear, however, is that if management is necessary it must ensure that a reserved area "... shall not be used or developed for any purpose inconsistant with that purpose or those purposes..." for which it was reserved (Forest Amendment Act,1973). Historically management has been towards that of an 'ecosystems approach' and the primary objective has been to prevent change within this ecosystem. Such an approach has often resulted from a lack of knowledge from which intervention may be justified. Indeed there is often a need for intervention where a highly valued feature is endangered. In these circumstances the 'featured species' approach may best ensure the survival of a valued species. An example of this is the fernbird, where habitat modification is necessary for their survival. It is conceivable that a 'feature' (value) may be of such worth that all others are sacrificed for it.

From a balanced use point of view these two approaches are alike. The predominant use on any piece of land being for the protection of the primary value, whether this be a featured species or an ecosystem. In either case compatible secondary uses will depend on the nature and requirements of that value reserved. Broad guidelines for acceptable uses of ecological areas have been suggested by the Scientific Co-ordinating Committee (in NZFS,1983). These are:

(1) Values of reservation must not be jeopardised unless the alternative use can be shown to be in the national interest.

(2) A multidisciplinary scientific panel will advise on the management of each reserve.

(3) Public access should not be excluded except in special circumstances, however entry may be restricted by permits.

(4) A system of walking tracks for visitors should ensure protection of susceptible or rare plant or animal species.

(5) Management plans for each reserve should indicate the intensity of public use and the types of recreational or educational activities which are desirable.

(6) No road access should be constructed.

(7) Untracked portions of reserves should remain in their natural state.

(8) Domestic stock should be excluded.

(9) Policies for the management of eradication of alien plant species should be established.

(10) Under the provision of the Mining Act 1971 and its subsequent amendments, ecological areas can be open to prospecting and mining, subject to stringent conditions to preserve ecological values.

(11) It is also recommended that wild animals be permanently reduced in ecological areas.

Management must thus first look to maintaining preserved values and may then consider compatible secondary uses.

Within Pikiariki the prime value is the kokako. It is a featured species, thus reserve management must be towards ensuring its survival. In practice, however, this management will be biased towards an ecosystems approach; that is, severe modification of the habitat is inimical to kokako survival. The result is that management will be largely preventative; of introduced modifying and harmful natural influences. By default this will provide the same protection for other bird and plant species that it does for kokako.

The important point is that the <u>objectives</u> are towards a 'featured species' approach, even if in practice this preserves the ecosystem as a whole. It may thus be feasible to re-establish indigenous seedlings, fell and extinguish burning totara or salvage windthrown trees if it is shown to be in the best interest of kokako. To ensure that such measures are given due consideration, proposals will be put before a multi-disciplinary scientific panel who will better understand the implications of management.

Furthermore, by 'zoning' the reserve, recreation a secondary use, may be incorporated in areas where it is compatible with the primary protection role. The Pureora State Forest Park Advisory Committee will finally consider the desirability or otherwise of proposed management and their recommendations or objections will be noted before a management plan is implemented.

6.2 INDIGENOUS RE-ESTABLISHMENT

6.2.1 Introduction

It is apparent from section 5 that any long term management of Pikiariki must involve the rehabilitation of existing forest and re-establishment of indigenous forest on neighbouring land. The aim of these measures will be to provide a suitable habitat, of adequate shape and size, in which kokako and other indigenous birds will remain viable.

This form of management is complimentary with the other proposals; that is, there is little point in reducing predator and browse pressure if the habitat is not itself adequate. Similarly there is no logic in costly re-establishment programmes if predators bring kokako to extinction.

The exact nature of the indigenous re-establishment programme will vary with site. Broadly speaking there will be two approaches to re-establishment:

(1) Enrichment planting in selectively logged and badly windthrown areas.

(2) Revegetation of surrounding exotic forest and cutover areas.

These areas are shown on map 7. Within each area re-vegetation should be such that it restores the forest composition and structure to resemble forest before man's intervention. By so doing, a habitat capable of supporting kokako and other forest birds will be provided.

Management to achieve this end requires an understanding of the basic regeneration patterns of the local podocarp forests. One may then use this knowledge to manipulate natural processes and provide the required high-forest more rapidly. Trials conducted in the Pikiariki area and in neighbouring forests provide valuable information for this management.

6.2.2 Management Considerations - Indigenous Re-establishment

Studies by McKelvey (1963), Beveridge (1973) and Herbert (1978; 1980) have provided much knowledge on the podocarp forests of West Taupo. From this work several basic principles of relevance to revegetation management must be considered.

Two factors have been described as pre-requisites to the regeneration of podocarps (Herbert, 1978):

(i) Viable native bird populations, including bellbirds, pigeons and tuis for seed dispersal.

(ii) Suitable sites for regeneration, including stands of manuka, kanuka and other small leaved or non-vigorous hardwoods.

Although seedfall and subsequent germination occurs under high forest, seedlings are largely ephimeral; apart from locally where they occur under Kamahi and broadleaf trees which provide light conditions favourable for podocarp regeneration or on riparian sites (Herbert,1978). Where canopy gaps or lightwells are created in selectively logged forest, vigorous light obscuring plants like treeferns, wineberry and fuschia are inimical to podocarp regeneration (Beveridge,1973; Herbert,1978). Furthermore treeferns produce a deep dry litter which is unfavourable for podocarp regeneration.

Burnt cutover areas left to revert will, in the absence of podocarp advance growth, be vigorously colonised by mesophytic shrub hardwoods such as pate, five finger, rangiora, fuschia, wineberry and Coprosma spp (Herbert,1978). These being the cover types which tend to inhibit podocarp regeneration.

In Pikiariki, it is therefore likely that viable podocarp regeneration will be excluded from selectively logged and windthrown areas by more vigorous and light demanding treeferns and mesophytic broadleaf species. Similarly competition on old cutover land and in pine plantations will prevent successful podocarp regeneration on land adjacent to the reserve.

With time, the natural processes of succession will render the forest more suitable for podocarp regeneration which will occur under large old kamahi and broadleaf trees (Beveridge,1973)(Appendix 12).

On the neighbouring cutover and afforested sites podocarp recruitment will occur if, in time, suitable nurse crops develop and seeds are dispersed by native birds. The time involved in such cyclic and successional processes are, however, considerable. Beveridge (1973) notes how the cyclic regeneration of podocarps may take 200 to 300 years from time of windfall of a mature podocarp until the next generation of pole podocarps is established.

Herbert (1980) described four stages in the growth of podocarp seedlings. He suggests that an initial slow growth stage is the result of partial suppression by the overstorey and that the second rapid growth stage coincides with the poles' penetration of the nurse crop. For the purposes of management this indicates the expected response when podocarp seedlings are released from competition.

The regeneration patterns described have considerable bearing on artificial revegetation:

(1) Firstly; the sporadic fruiting of podocarps, and the time taken for birds to disperse seeds and for these to germinate may be reduced by nursery production and planting.

(2) Secondly; the site on which these seedlings are established must be free of competition and maintained like this for maximum growth.

6.2.3 REVEGETATION PROGRAMME

(1) Seed Collecting

Seed collected must be of local origin, to prevent genetic pollution and to ensure good survival and growth.

Many podocarps have irregular seedfalls. This will create problems of seed supply and require that there be a degree of flexibility in revegetation programmes. The compilation of a register of seed trees will be a useful aid in identifying high seed producing and superior trees.

(2) Seedling Production

The production of podocarp seedlings in 'bush nurseries' was tried on an experimental basis in a series of trials in and around Pikiariki reserve. The results showed that such operations are not economically viable, also seedling survival and growth rates are unsatisfactory (Taylor,1983).

The Cambridge Nursery has produced seedlings of superior quality and these are more consistently available than from bush nurseries. In the nursery, stock are hardened off and good root development is achieved by undercutting (Taylor,1981).

Stock should be open rooted, as trials in Pureora have shown that no apparent advantage in growth is obtained from using potted stock, whereas they cost significantly more (NZFS,1982). Furthermore stock should be between 60cm and 120cm in height. This will help to overcome weed competition, also supply will be spread out over a number of years as those that are too small grow on in the nursery.

(3) Establishment

Stocking - Stocking rates will vary between modified and old cutover and afforested sites. The aim is to replace the podocarp component removed by logging or windthrow. Each site must be assessed for residual stocking and species composition, and a planting prescription drawn up, so that the original composition of around 80% rimu and 20% kahikatea, totara and matai may be restored (ie. M_1 and M_2 forest)(NZFS,1982).

Allowance should be made for seedling mortality and for variation in vigour. A rule of thumb is that one tree of good form will be obtained from nine seedlings (Appendix 13). Stocking rates will therefore range from 33 groups per hectare in selectively logged forest to 60 groups per hectare on cutover and badly windthrown sites.

The methods of re-establishment will depend on whether the site in question is (a) modified podocarp forest or (b) old cutover and afforested land.

A. Modified Podocarp Forest (See Map 2)

Within the badly windthrown and selectively logged areas of Pikiariki, podocarp regeneration will be impeded by vigorous and light demanding hardwoods and tree ferns. Good quality seedlings must be planted and severe competition prevented.

Establishment between the months July and September, will involve careful choice of microsite, ensuring that the planting site is subject to full overhead light but with side shade if possible. Well drained moist ground with good humus and topsoil cover will be best. Site preparation should involve hand clearing of competing vegetation and possibly a spray with velpar. The site should then be screefed and the seedling planted in a well cultivated hole. The position of each cluster of three seedlings will be marked and recorded on a map. Trials in the Pureora area have shown fertiliser to have no significant effect on growth of podocarp seedlings (Taylor, 1982a).

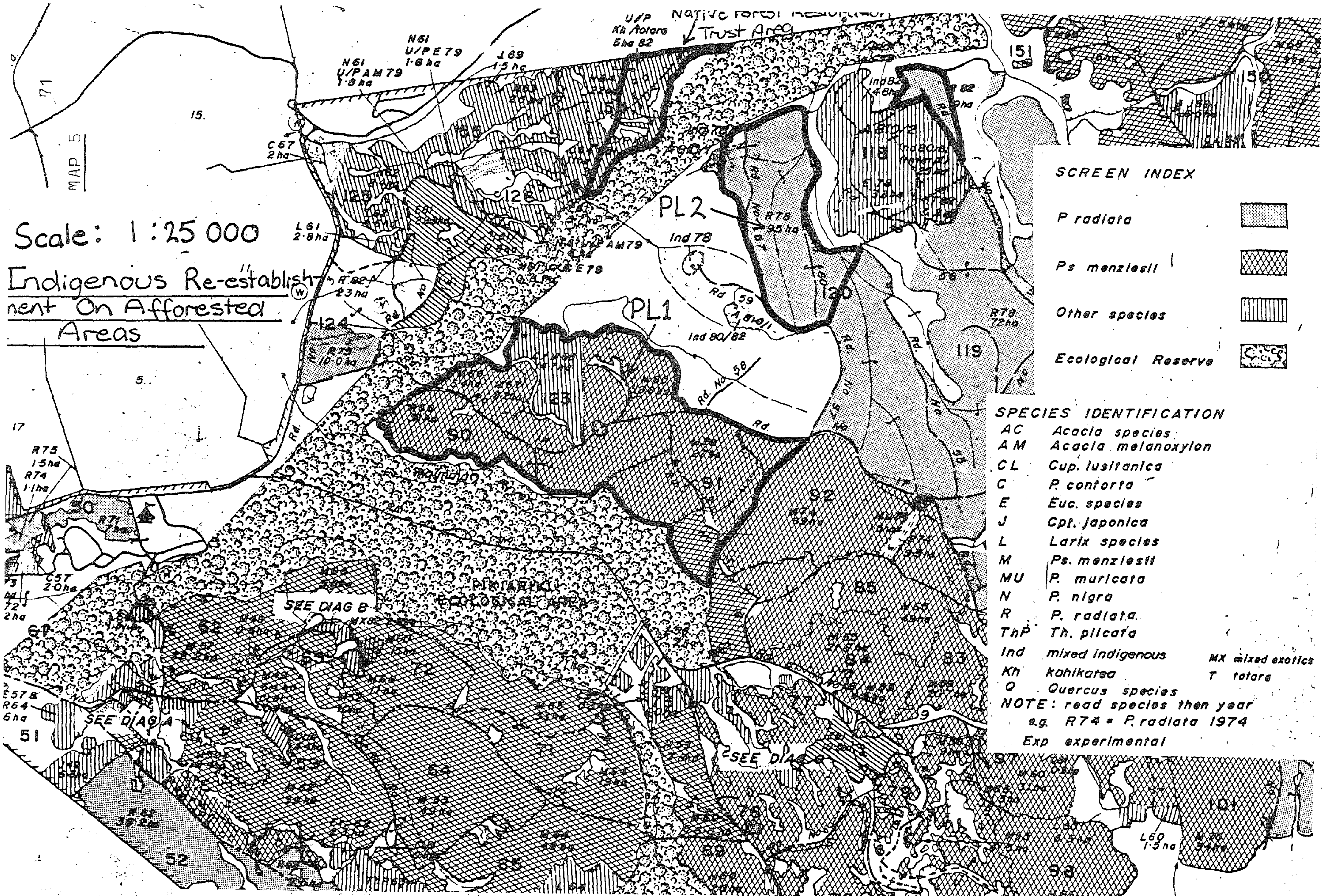
Frequent releasing will be necessary to prevent seedling suppression. This is generally done by hand (ie. slasher), however a trial in Pureora has given indications that Roundup plus Simazine may give effective control of most weeds. Releasing must be repeated until the podocarp seedlings have grown past the competing weeds.

B. Old Cutover and Afforested Sites (See Map 5)

The areas on map 5 include indigenous re-establishment trials (Appendix 14) and exotic forest to be converted to indigenous forest.

(i) Old Cutover Sites

On these sites indigenous re-establishment trials have been set up. Their success has varied but their findings have important implications for further



MAP 5
Scale: 1:25 000
Indigenous Re-establishment On Afforested Areas
Native Forest Restoration Trust Area
PL1
PL2
SEE DIAG A
SEE DIAG B
SEE DIAG C
SCREEN INDEX
P radiata
Ps menziesii
Other species
Ecological Reserve
SPECIES IDENTIFICATION
AC Acacia species
AM Acacia melanoxylon
CL Cup. lusitanica
C P. contorta
E Euc. species
J Cpt. japonica
L Larix species
M Ps. menziesii
MU P. muricata
N P. nigra
R P. radiata
ThP Th. plicata
Ind mixed indigenous
Kh kahikatea
Q Quercus species
MX mixed exotics
T totara
NOTE: read species then year
e.g. R74 = P. radiata 1974
Exp experimental

indigenous re-establishment work on cutover sites:

(1) Although *Eucalyptus delegatensus* is generally a good nurse crop, *E. regnans* may be better for periodically dry and frosty sites.

(2) Hot dry winds may cause high mortality in podocarp seedlings and should be alleviated by establishing a nurse crop well before podocarp underplanting. Blanking may still, however, be necessary.

(3) Seedlings established on bare pumice sites are likely to have high mortality rates because of poor soil fertility.

(4) The presence of regrowth is an indication of soil fertility. These are the microsites on which seedlings should be planted.

(5) Vigorous weed growth, especially bracken fern, and wineberry, will suppress podocarp seedlings and thus should be controlled.

(6) Browsing is potentially a problem, with kahikatea being more affected than other podocarps. The likely culprits include; deer, rabbits, hares and possums.

These trials will continue to provide valuable information on indigenous re-establishment techniques. Future management will involve planting of *E. regnans* on dry frosty sites and the thinning and felling of the nurse crops when they become superfluous or inhibitive to the podocarp underplantings.

(ii) Afforested Sites

It is proposed that the areas marked as PL_1 and PL_2 on map 5 be converted to indigenous forest. This will increase the total area of Pikiariki to around 800 hectares and will, in the long term, impart greater stability on the reserve by increasing its 'compactness'. In around 200 to 300 years time these areas should provide suitable kokako habitat.

Exotic forest growing on these sites is composed of douglas fir, radiata and contorta pine (Map 5). Conversion will only begin after the predator and browse control operations have shown success.

An indigenous re-establishment programme has already been put into action by the Native Forest Restoration Trust who underplanted sixteen hectares of 1964 *Pinus nigra* with kahikatea, totara and a few hardwoods in 1981 and 1982 (Map 5). Seedlings were planted in enlarged gaps and some in cut lines. Growth and survival appear to be reasonable (R.Guest pers comm 1984).

The young radiata stands (PL_1) will be converted first. This will involve strip felling and the residual strips will remain as a nurse crop. Area PL_2 will be converted over several years, progressively towards the south. Strip felling will be used to maintain side shelter for podocarp seedlings.

Planting will be as described for modified sites (Part A) and releasing will be important as both indigenous and exotic weeds, such as blackberry and pampus will suppress seedlings and restrict access.

The exotic nurse crops will require thinning to maintain stand stability and edge-pruning may be necessary if edge trees suppress podocarp seedlings. When the nurse crop becomes superfluous or inhibitive to underplantings it should be felled and extracted, if possible; otherwise ringbarking will prevent excessive damage to underplantings. Podocarp seedlings will be established on cleared strips or under dead, ringbarked, trees.

These operations will be costly in terms of establishment and logging costs as well as considerable opportunity costs involved with the removal of productive forest. Some returns may be realised from douglas fir removed at establishment and from the nurse crops, if they are extracted.

The area described for conversion represents a minimum only; ideally the reserve should be larger still and perhaps even continuous with the Pureora Mountain Ecological Area. Proposals for further expansion should be reviewed in the future, pending results from Pikiariki.

6.3 KOKAKO PREDATOR CONTROL

6.3.1 Introduction

The realisation that predators are a significant threat to the longevity of the kokako is implicit in the Forest Bird Research Group's (1981) recommendation that;

"An experimental control operation for predators should be commenced so that the potential for larger-scale control can be assessed."

This was spurred by the heavy rate of predation on kokako nests during the three year research period. It is clear that this pressure, left unchecked, is likely to hasten extinction of the Pikiariki kokako population. Any further forms of management to maintain kokako will be futile if it is not possible to maintain a breeding population.

The main predators in Pikiariki are rodents (rats and mice) and mustelids (stoats and weasels). Ship rats and stoats are considered to be the greatest danger to kokako (Innes,1984). Management must aim for the control of these animals.

6.3.2 Management Considerations - Stoat Control

During the nineteenth century intensive and sustained trapping was carried out in England to eliminate mustelids which were threatening game birds. Such a 'gamekeeping' approach proved to be unsuccessful, however, as it failed to achieve long term reduction in stoat and weasel numbers (King & Moore,1979).

Resistance to trapping was chiefly attributed to the reproductive strategies of both stoats and weasels, that is they are r-strategists (King & Moore,1979). Such strategists have characteristics including; early maturity, large litter size and more than one litter per adult females lifetime. The survival of young is, characteristically, mainly influenced by the availability of food. The result is a typically short r-strategist lifespan (King & Moore,1979). King and McMillan (1982) found that few young live as long as one year.

Trapping is therefore ineffective because those killed in traps will not exceed the large natural mortality and high productivity during years of plentiful food will quickly result in the replacement of those that are killed (King & Moore,1979). Trapping appears to be of use only on a local and temporary basis. King and McMillan's (1982) work in beech forest showed that "...trapping may be very successful for a few months in summer and autumn after a seedfall but thereafter swiftly becomes unproductive."

Stoats may also travel long distances, therefore immigration into a trapped area will occur (King & McMillan,1982).

Where small areas need protection, for example an endangered bird's nest, a degree of effectiveness may be achieved by concentrating control on the nesting site over the nesting period.

Under the recommendation of the F.B.R.G. an experimental control operation was conducted by the Forest Research Institute (F.R.I.) in Pikiariki over the 1982 to 1983 summer (Innes,1984). Tracking tunnels were used to obtain indices of predator numbers and an intensive trapping operation was carried out using fenn traps for stoats, and poisons and snap traps for rodents (Innes,1984). Comparisons were made with a 'control area', where there were no trapping operations.

The results obtained from the tracking tunnels were inconclusive, however a pair of kokako fledged; at least an indication of success.

6.3.3 Guidelines For Stoat Control

The aim of stoat control operations will be to protect kokako at the time they are most vulnerable to predation, that is while nesting. The methods used will be those used by Innes (1984) as described by King and Edgar (1977).

(1) Identify Control Area

Predator control operations are expensive so it is important that effort and expense be concentrated on areas where control is most needed.

An intensive territory mapping exercise (Appendix 15) will be used to identify areas where kokako pairs, and therefore potentially nests, are. This exercise will be concentrated in the areas where kokako have been identified on map 3 . Particular attention should be paid to locating nests.

(2) Kill Trapping (Appendix 16)

The Mark IV Fenn trap is an effective and humane way of trapping stoats (King,1980). Tunnels placed over these traps will protect non-target birds from

Plate 11: Stoat in MK IV Fenn Trap
(Photograph by C M King)

Plate 12: Protective tunnel for the Fenn Trap
in the background.
(Photograph by C M King)

harm, however interference from possums, hedgehogs and rats is likely.

Ideally traps should be set at a density of forty to fifty per hectare (King & Edgar, 1977), however because of the scale of operations proposed and low stoat numbers in Pikiariki (C M King, pers comm) this is not practical. If stoat numbers should increase with a heavy podocarp fruiting then more intensive trapping may be necessary. Innes (1984) used approximately one trap per hectare. This density will effect some control but more importantly will provide information on stoat numbers and indicate if more intensive trapping is necessary. If kokako nests are located, concentrated trapping around them will afford extra protection.

Trapping will commence at the beginning of January, corresponding with the commencement of the rodent control programme. Traps will be cleared and fresh bait (Felix fish cat food) applied every second day or daily if stoat numbers are found to be high. Trapping will cease when the rat control programme does, that is when no more rats or stoats are caught (around late February).

6.3.4 Management Considerations - Rodent Control

Rodents have been present in New Zealand since the introduction of kiore (*Rattus exulans*) with the arrival of the Maori. The last of New Zealand's four rodent species to arrive was the ship rat (*Rattus rattus*) and it is believed to have arrived around the mid-nineteenth century. Also present are the Norwegian rat (*Rattus norvegicas*) and the house mouse (*Mus musculus*) (Campbell,1976).

The economic significance of these rodents has been recognised since the beginning of agriculture and grain storage. In New Zealand they have undoubtedly had a significant impact on the indigenous forest ecosystems.

The diet of both the ship rat and the mouse comprise vegetative as well as animal foods. Best (1969) and Daniel (1973) found them to be opportunistic feeders with seasonal variations in diet. Basic foods are berries, seeds, nuts and arthripods. Birds were found to be eaten only occasionally where ship rats have been present for some time (Best,1969; Daniel, 1973).

With seasonal variations, rats tend to eat mostly seeds in autumn and winter, and animal foods in spring and summer (Daniel,1973). Rodent numbers are generally low in early summer (December) but increase rapidly to peak in autumn (Daniel,1976; Moors,1976; Hay,1981). This increase corresponds with podocarp seedfall, indeed Beveridge (in Daniel,1973) has noted how ship rats may consume large quantities of podocarp seed.

Ship rat populations increase rapidly as food becomes available; indicating a high reproductive capacity. In seasons of plentiful food females will mature earlier, have larger litter sizes and the breeding season will be lengthened.(Daniel,1973). Winter food shortages and predators, particularly feral cats and stoats, appear to be the main factors controlling ship rat populations (Daniel,1973). The population patterns of mice are similar to those of rats, that is their numbers increase with a podocarp seedfall (Hay,1981).

In a forest rats are spread fairly evenly in territories. An unoccupied territory will rapidly be reoccupied by a neighbour (Innes,1984).

The biological factors discussed above pose many problems for the control of rodents and preclude any thoughts of their eradication. A large population may quickly build up from a small breeding population and local eradication, if achieved, would only result in rapid re-invasion.

Over man's agricultural history various control methods have been devised; including types of biological, chemical and non chemical control (Wodzicki, 1976).

A suitable method for Pikiariki will be one that protects kokako at the time they are most vulnerable, that is nesting. It must aim to lower rodent numbers around kokako nests at this crucial reproductive stage.

Just such an operation was conducted by F.R.I. in Pikiariki. It involved chemical control, trapping and surveillance. These measures were integrated with the stoat control operations used over the summer of 1982 to 1983 (See section6.3.2). The results showed a significant decline in rat numbers compared with an untrapped 'control area'.

6.3.5 Guidelines For Rodent Control

These are based on the methods used by Innes (1984) in Pikiariki.

(1) Control Area

Operations will be confined to the kokako breeding areas determined by territory mapping and described in section 6.3.3. This operation will be integrated with the stoat control programme to minimise travelling time, man hours and dollars spent.

(2) Chemical Control (Appendix 17)

An anticoagulant poison Brodifacoum, marketed in parrifin blocks as "Talon WB", shall be used. Baits will be covered with tunnels to protect birds and may need to be pegged down to prevent possums from interferring with them. Baits will be pulsed (renewed) regularly as animals that have already ingested a fatal dose will continue to take baits for several days (Innes,1982).

Operations will commence at the beginning of January, corresponding with increasing rat numbers, and they will continue until baits cease to be gnawed.

(3) Surveillance (Appendix 18)

Tracking tunnels will be established, on the ground, at the beginning of December and cleared monthly until the end of February, or March if indices are still high. They should be established on a grid, at around 100 metre intervals, in the trapped area as well as in area B, the area used by Innes (1984) as a 'control' for his poisoning and trapping operations.

From points left on the tracking papers it is possible to distinguish the species of animal and to calculate a frequency index. Using these indices, poisoned areas may be compared with the non-poisoned 'control' area to gauge how effective the operation was.

Plate 13: A tracking tunnel high in a totara. Tree tracking gave few prints and has now been abandoned.

(4) Kokako Surveys

The ultimate success of these operations is not indicated by lower animal indices but by successful kokako preservation and breeding. Kokako will frequently be seen whilst workers are tending to control apparatus and these sightings should be recorded.

Changes in population structure may be observed with monthly surveys of the breeding areas. It will be important to note if adult birds are missing or fledglings are present in an area. To assist in following population patterns individual birds should be tagged (Appendix 19). It will then be possible to note if a particular bird has died or dispersed or if a newly fledged bird is present.

6.4 BROWSING MAMMAL CONTROL

6.4.1 Introduction

As a part of the Forest Bird Research Group's (1981) work, the feeding habits of possums and the possible consequences of this feeding on the kokako were investigated. From their findings they recommended that "The control of browsing mammals in areas of high kokako density should be accorded high priority."

For successful preservation of kokako and to minimise damage to revegetation sites, it is important that deer and possum numbers are not allowed to increase and ideally they should be decreased.

6.4.2 Deer Control

Deer have not been present in high numbers in the past and, because of commercial and recreational hunters, they are still only at a low level in Pureora Forest Park (Leathwick,1981;1983). This hunting pressure will maintain deer at low levels and Pikiariki's close proximity to Pureora Village will afford it extra protection.

If it is found to be necessary, government control of deer may be introduced under the 1977 Wild Animal Control Act.

6.4.3 Management Considerations - Possum Control

Like deer, possums are recent arrivals in Pureora. Unlike deer, however, they have continued to increase in abundance and present an urgent need for control.

Recently possum control has involved the use of poisons, chiefly cyanide and 1080 (sodium monofluoro-acetate). These have generally been effective in controlling possums, but some concern has been voiced over the danger they pose to birds. In the 1970's, 1080 operations were associated with significant bird mortality (Warren,1984).

More recently, improved bait preparation has virtually eliminated this danger, however, because of inadequacies in survey method, no conclusive results have been obtained for the rarer and long-ranging birds (Warren,1984; E Spurr _pers comm_,1984).

Furthermore birds which spend a proportion of their time on the ground are placed at greater risk by poison and traps. The kokako spends a small part of its time at ground level and the robin is constantly near the ground. This would appear to place these birds at greater risk.

This situation poses one of the classic ecological area management dilemmas; to sustain kokako possums must be controlled, however the control measures may themselves place the kokako in danger.

6.4.4 Guidelines For Possum Control

Despite the potential dangers that exist, possums must be controlled. There are methods which appear to be safe but are unproven for kokako. These must be incorporated into a sensible control plan that will; (1) provide effective possum control and (2) give results related to control and effects on the avifauna.

Recently possum control measures have been implemented at the forest margin to control the spread of bovine tuberculosis onto neighbouring farmland (Appendix 21). 1080 poison was placed in flower pots and elevated by a length of wire (Appendix 21). This provides protection from rain and may offer protection to birds. The only birds reported dead after the operation were some blackbirds (R Guest *pers comm*, 1984).

A similar method used in areas of kokako habitation may provide safe control. It will be important to use a bait that is unattractive to birds. Such 1080 preparations have been manufactured.

Innes (1984) noted how Talon poison, under protective covers was frequently interferred with by possums. It is possible that a suitable bait (cyanide) and lure used under such covers will bring a similar response from possums. They may be designed so possums can gain access easily but provide some protection to birds. Death from cyanide poisoning will be instantaneous and will thus enable assessment of kill success. Any birds killed will also be at the bait station, that is if not removed by stoats or rats.

Such an operation must be well planned and conducted as a trial. Assessment will be an important factor in the operation.

6.5 RECREATIONAL MANAGEMENT

6.5.1 Introduction

The role of recreation within Pikiariki has been recognised as of secondary importance and thus should not contravene the primary wildlife conservation and soil and water protection objectives. An increase in recreational pressure may, however, be accommodated by careful zoning and management of the forest area. Appropriate recreational uses may be catered for by concentrating them in areas where they will be least harmful to wildlife, soil and water.

6.5.2 Management Considerations - Recreation

Section 4.5 identified the most likely recreational group to use Pikiariki as being the passive recreationist, including bird and nature enthusiasts, photographers and school groups. It was also noted that, because of relatively long distances from major urban areas, overnight camping will be required by many visitors.

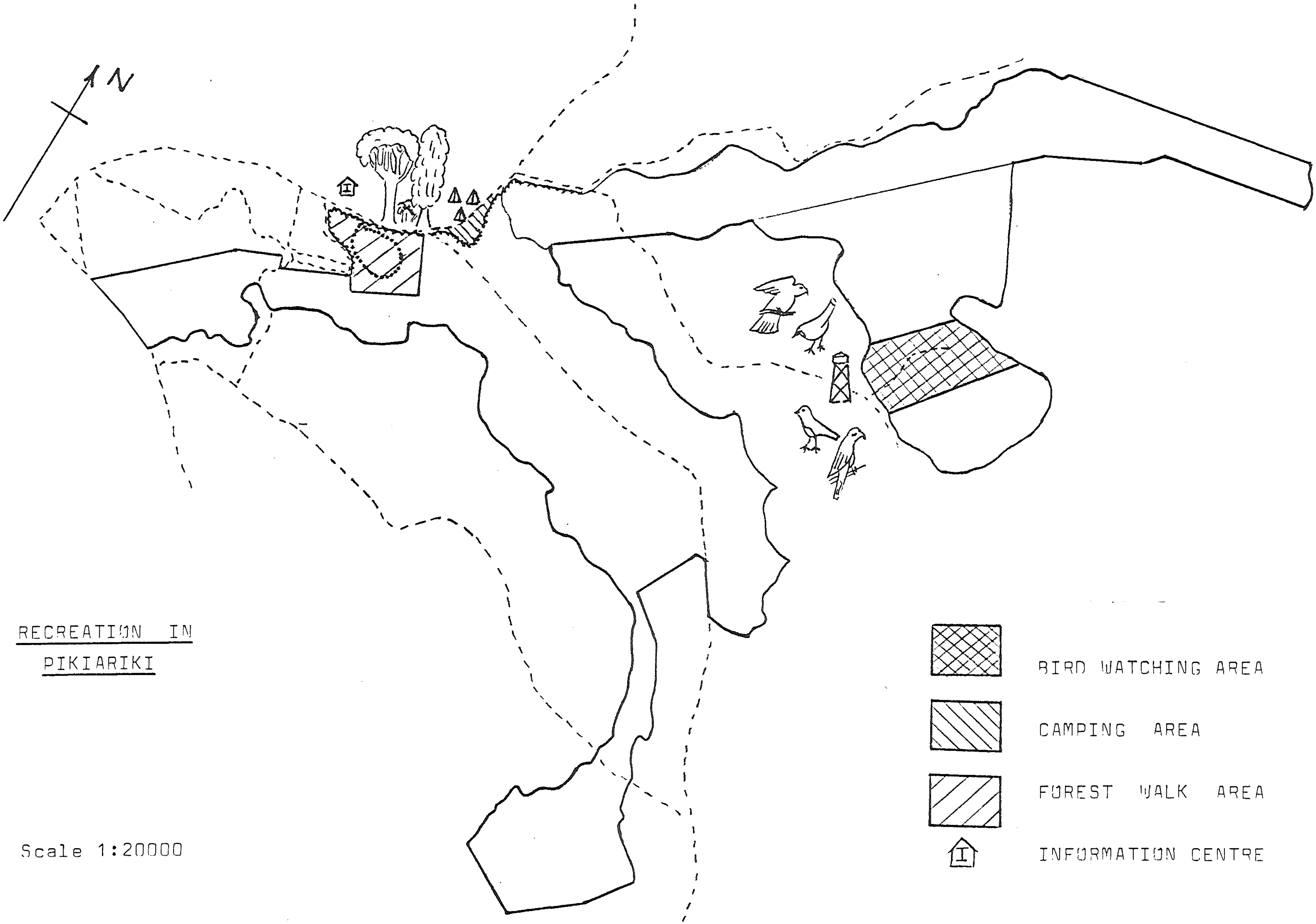
Recreational management should cater for this section of the recreating public. The more active pursuits of tramping and hunting are better suited to more extensive areas of the Forest Park. Hunting pressure on Pikiariki will not be great and will mainly be from locals.

At present public facilities in and around Pikiariki include a short bush walk (Totara track) an information centre and the Ngaherenga camping area. There exists little facility for bird enthusiasts who may find that birds such as the kokako, parakeet and kaka exist only as songs deep in the forest or as colourless silhouettes. This may encourage the bird watcher to pursue the birds into the forest; an activity that should not be encouraged. Trampling within the forest will disturb forest floor vegetation and upset predator control operations.

6.5.3 Guidelines for Recreational Management

Recreational development will involve the zoning of three areas, as on map 6 :

MAP 6


N
RECREATION IN PIKIARIKI
Scale 1:20000
BIRD WATCHING AREA
CAMPING AREA
FOREST WALK AREA
I
INFORMATION CENTRE

(1) A bird watching area

(2) A forest walk area

(3) And an overnight camping area.

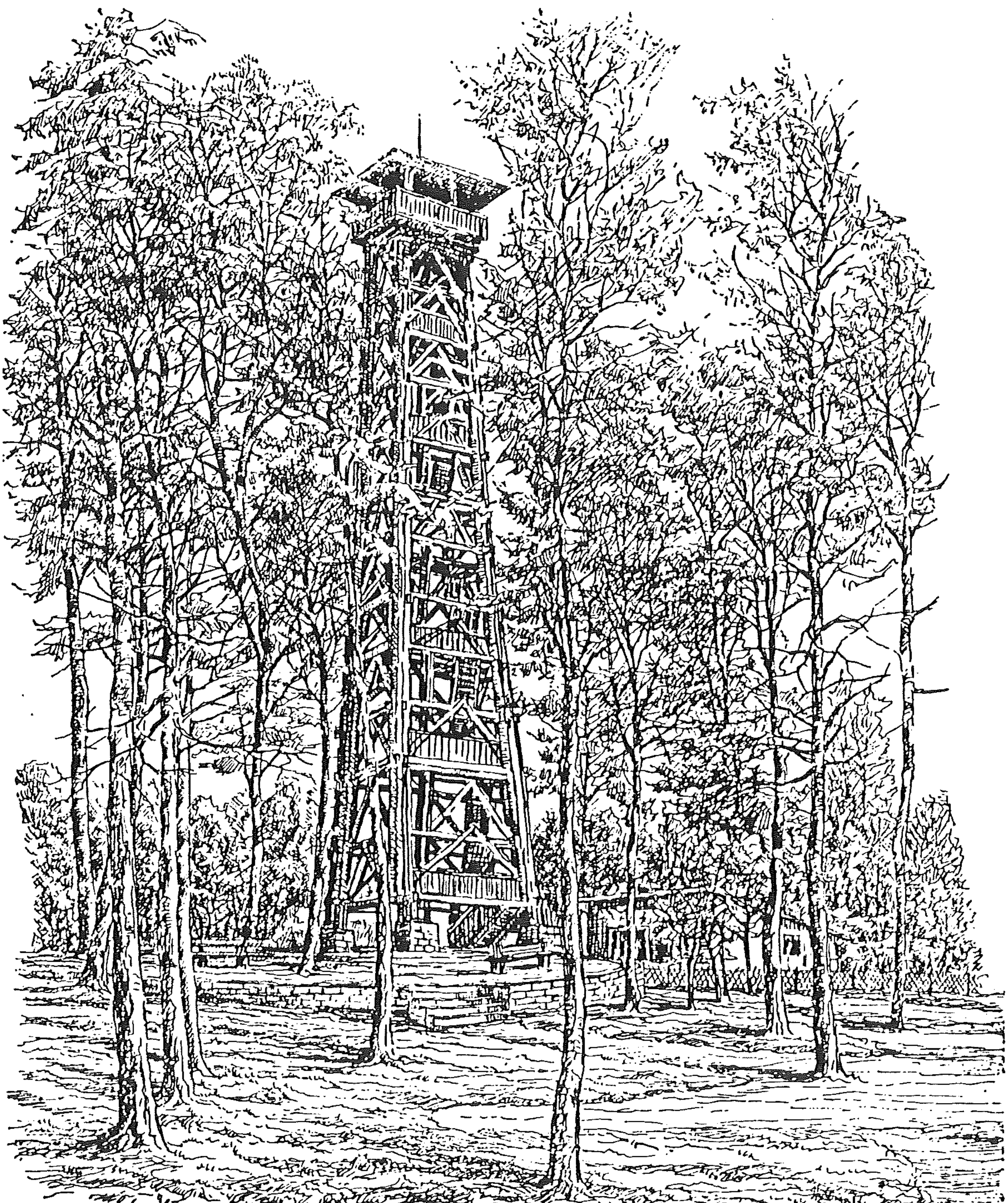
(1) Bird Watching Area

This area includes type M_1 forest which contains a moderately high density of kokako, kaka, parakeet and other birds. Bismark Road allows access to its centre and an old landing at roads end provides good vistas of surrounding rimu and totara. Within the crowns of these trees kokako and other avifauna may often be seen.

These birds are often high in the canopy, however, and are not easy to see. A situation providing little potential for satisfying the bird enthusiast or photographer. A suggestion offered by District Forester, Rob Guest, would largely overcome this. He noted that a tower erected for Television New Zealand allowed the observer to gain a completely new perspective of the forest, a 'birds eye view'. When birds were sighted they were often close and because of better light conditions their true colours were clear (R Guest, 1981).

A tower built in this area will provide for most of the bird watcher's needs and thus leave little need for moving off tracks. Towers of this sort are not common in this country but are more so in Europe. Figure 1 depicts a large tower (approximately 43 metres high) in a German Park (Ruppert, 1960). It should be placed between podocarps and careful con-

FIGURE 1



Large Viewing Tower in Germany (Ruppert 1960) struction will ensure that a minimum of vegetation disturbance occurs. Access to the tower should be via a single walking track from the Bismark Road landing.

The tower design should be the responsibility of Engineering Division (of NZFS) but it should be approximately twenty metres tall and made of timber so that it does not look too obtrusive. Guest (1981) suggests that treated wood foundations be used but that locally produced larch thinnings could be used for rails. This timber is naturally durable and would enhance the 'natural' appearance of the tower.

This will not be without some dangers which must be recognised:

(a) There may be an increase in rat numbers with the presence of people, especially if food scraps are dropped.

(b) There will be trampling of bush if users leave the track.

(c) Predator control devices could be interferred with thus reducing their effectiveness and possibly place users in danger.

(d) There is a danger of people falling from the tower and of windfallen trees or limbs damaging it.

The above dangers may be minimised by good public relations, communication and planning. It is important to stress to the public that they should not leave the tracks or eat within the forest, for the sake of the forest ecosystem and for their own safety. If they eat on the trackside or at the tower they must take their scaps out or place them in bins provided.

Any dangers associated with the tower may be minimised by good design but the public should be notified of the risk. It may be necessary to close the tower on very windy days. The NZFS would not, however, be liable for any accidents which are covered by the Accident Compensation Act 1972.

(2) Forest Walk Area

This area encompasses the Totara Walk and recreational developments will only be refinements of what already exists. The area contains no kokako and will not be involved in predator control operations. Offered will be an easy loop walk through dense podocarp forest (L_1 type). Despite the absence of kokako there is still a good diversity in birdlife within this forest.

Development will include the positioning of informative plaques describing forest vegetation. These will be tied in with brochures which will be available at the neighbouring information centre.

Benches may be placed at the track-side for picnicking or resting. The public should be discouraged from dropping rubbish and rubbish bins will be a good investment.

(3) Camping Area

The Ngaherenga camping area is an important facility for those who have travelled from farther afield. Provided at present are; barbecues, firewood,

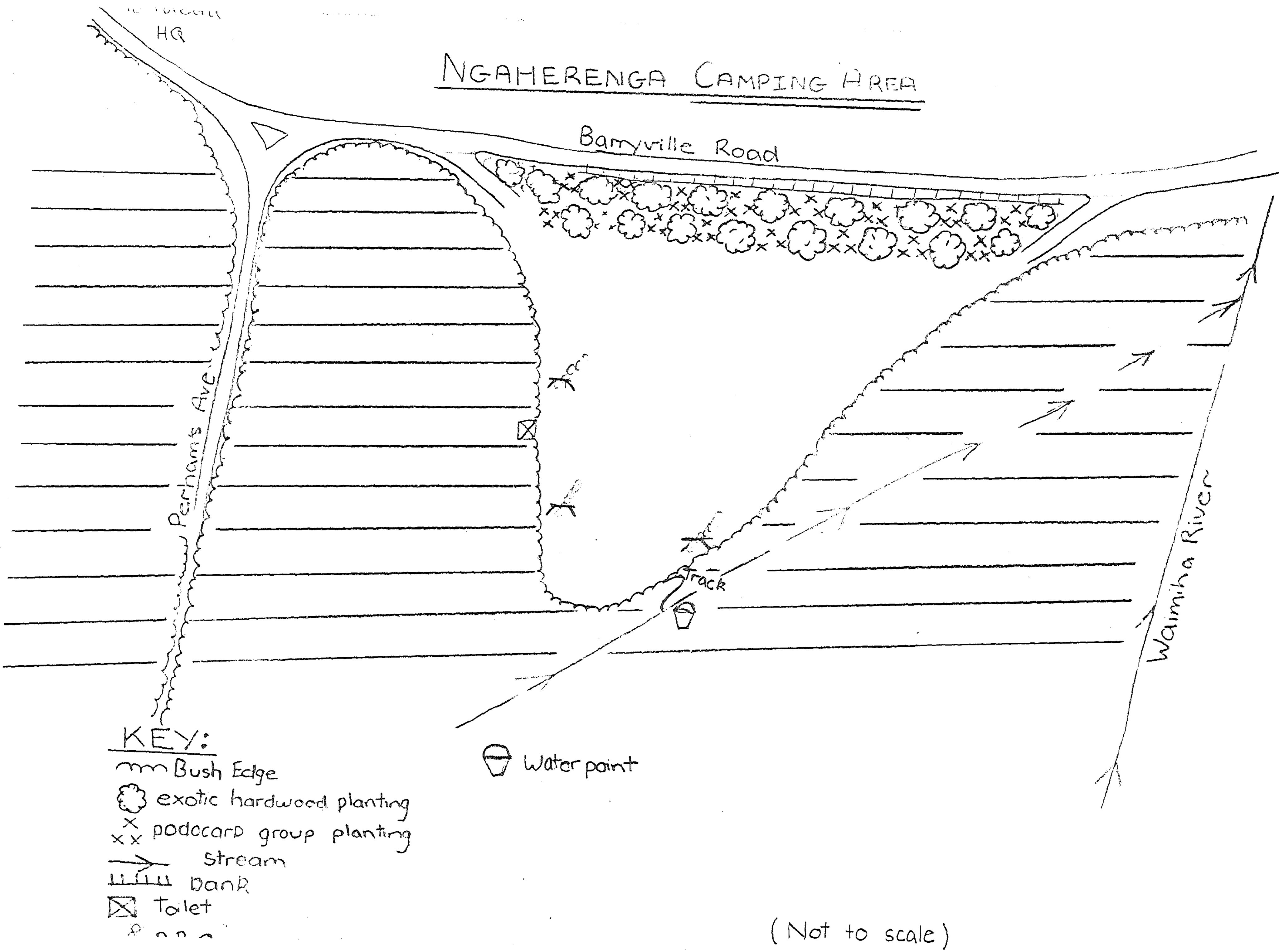

HQ
NGAHERENGA CAMPING AREA
Barryville Road
Perham's Ave
Track
Waimiha River
KEY:
Bush Edge
exotic hardwood planting
podocarp group planting
stream
bank
Toilet
Waterpoint
(Not to scale)

FIGURE 2

a toilet and fresh stream water, as well as mowed tent sites. Intensive development is not consistent with the minimal recreational development described, and indeed comments from many of those who use the camping area commend it for its "primitiveness" (Calder,1984).

The aesthetic value of the site could be improved by planting a belt of exotic hardwoods, underplanted with indigenous podocarps, along the roadside (see figure 2). This would put the camping area out of sight of Barryville Road, protect it from dust and help to develop a feeling of being within the forest in campers. Establishment of this belt will be as described in section 6.2 and should use *Eucaluptus* spp.

Education

The facilities described will be suitable to incorporate in education programmes for school groups and for visitors who participate in 'summer programmes'. These will require personnel with a good understanding of the forest ecosystem and historical points of interest. Currently the Forest Service employs an officer who is in charge of 'summer programmes' at Pureora.

It will provide an opportunity for the the public to see positive environmental action pursued by the Forest Service. The so often talked about kokako and other birds will be seen as a reality. The public will be informed of their plight and of positive action being taken by the Forest Service to preserve them. Such programmes are common in National Park information centres.

6.6 MANAGEMENT FOR SOIL AND WATER PROTECTION

Soil and water management will, in general, be an integral part of kokako management. The revegetation strategies will ensure that a vegetative layer is maintained to protect waterways from excessive sediment loading.

The Water Area (Map 7) will, however, be managed specifically for the maintenance of high quality drinking water. In this area no forms of recreational use, apart from hunting, will be incorporated in management. It is important to prevent vegetation damage and subsequent sediment yields as a result of trampling, tracking and deer browse. Possum control will be an important form of protective management for this area.

Further management may, depending on the circumstances, require that windthrown trees be removed from the Whareana Stream channel. Windfalls may result in damming, bank instability and excessive sediment loading. To prevent this it will be necessary to section and remove portions of trees from streams and side-streams. To minimise disturbance this will be done by men equipped with chainsaws and axes, not machines.

Revegetation will not be necessary in this area because the main objective of maintaining water quality is achieved with any vegetation cover, whether podocarp or hardwood (O'Loughlin,1978). A windblown site will quickly be covered by wineberry and treeferns, and in the short term planting and releasing gangs will probably do more harm than good by damaging vegetation.

A degree of protection will be afforded by leaving a buffer strip of exotic trees (douglas fir) around the perimeter. This should reduce windthrow which is likely to occur when surrounding exotic stands are clearfelled.

6.7 FIRE PROTECTION

Pikiariki is situated close to the Pureora fire station which would provide rapid detection and action if a fire occurs. Legislation for this protection is under the Forest and Rural Fires Act 1977 and the Forest and Rural Fires Regulations 1979.

Prevention should, however, be the first aim of management. Fire lighting should be prohibited in the forest and good barbecue facilities at Ngaherenga Camping Area will minimise the danger of fires getting out of control. Public awareness is important and the danger of fires will be emphasised to Information Centre visitors.

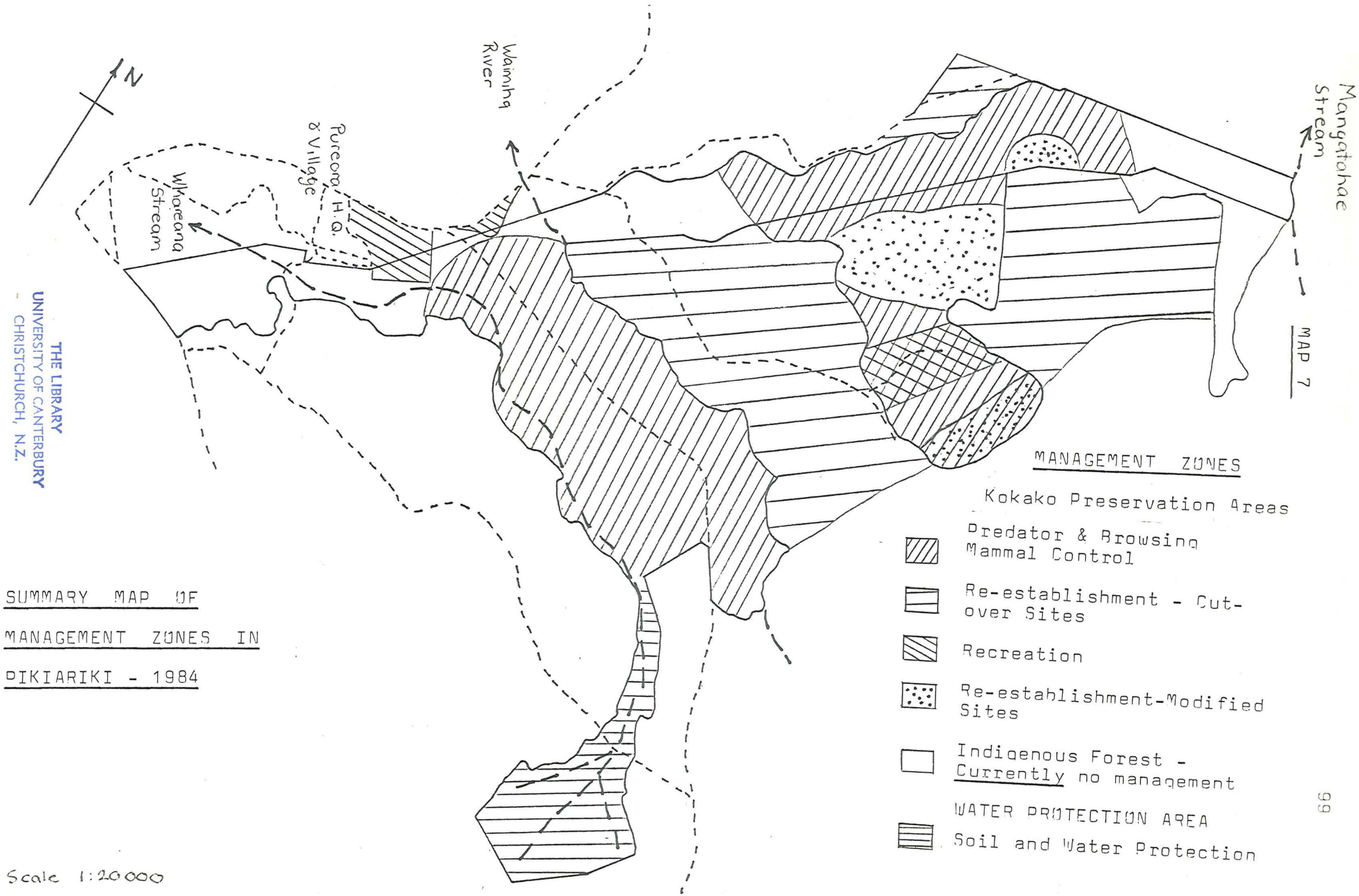
Burning of exotic forest areas for land preparation should not, in general, be permitted. The threat to forest and wildlife is too great to take such a risk.

6.8 RESEARCH

Much of what is proposed as management for Pikiariki is new and unproven. Very little is known of the direct and indirect effects of predator and possum control on the forest and its wildlife, especially those more rare birds.

Trials being conducted in windthrown parts of the Education Area will help resolve conflicting opinions on salvage logging. It is possible that on sight sawing of windfalls and then aerial extraction of flitches will ameliorate the site for podocarp regeneration and also provide a sawdust mulch which will reduce weed growth around planted seedlings.

Managers of ecological reserves may, as a result of work in Pikiariki, finally be confident in intervention to protect ecological values.



N
Waimiha River
Pureora H.Q. & Village
Whareana Stream
Mangatohae Stream
MAP 7
SUMMARY MAP OF
MANAGEMENT ZONES IN
PIKIARIKI - 1984
MANAGEMENT ZONES
Kokako Preservation Areas
Predator & Browsing Mammal Control
Re-establishment - Cut-over Sites
Recreation
Re-establishment-Modified Sites
Indigenous Forest - Currently no management
WATER PROTECTION AREA
Soil and Water Protection
Scale 1:20000

7. SUMMARY

Pikiariki is a reserve of considerable value. It contains a rare and diverse assemblage of indigenous birds and its forest type is a remnant of once extensive lowland podocarp forest. To locals it provides water and to the nation it offers recreational and scientific opportunities.

As a reserve, however, it is less than ideal. It is thwart with problems which threaten its existence, many of these are common to all of New Zealand's forest ecosystems, others are particular to Pikiariki and are largely a result of poor design. Management is essential to maintain the forest structure under the influence of wind, succession, fire and browsing animals and to protect kokako and other birds from predators.

Pikiariki provides recreational opportunities for those willing to travel some distance to admire its diversity in flora and fauna but recreational use must be restricted to protect wildlife and water values.

Management also faces problems concerning ecosystem manipulation, where the reserve is controlled for kokako survival. Predator and browsing animal control measures are largely unproven; their effectiveness and their influence on wildlife is not known therefore such management must be closely monitored and strictly controlled. The value of Pikiariki as an ecological reserve goes beyond its boundaries, it will provide valuable information for management of other reserves and may relieve recreational pressure from other more valuable areas; such as Waipapa Ecological Area.

Any management should be implemented with a long-term perspective in mind; the management suggested should be viewed as only a guideline and as knowledge, technology and society change then so should management.

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APPENDIX 1

Glossary of Scientific Names

Plants

Common Name	Scientific Name
Beech	Nothofagus spp
Blackberry	Rubus fruticosa
Broadleaf	Griselinia litoralis
Contorta	Pinus contorta
Coprosma	Coprosma spp
Douglas fir	Pseudostuga menziesii
Eucalypts	Eucalyptus delegatensus Eucalyptus regnans
Fivefinger	Pseudopanix arboreum
Fuchsia	Fuchsia excorticata
Horopito	Pseudowintera axillaris
Kahikatea	Podocarpus dacrydiodes
Kaikomako	Pennantia corymbosa
Kamahi	Weinmannia racemosa
Lancewood	Pseudopanix crassifolius
Matai	Podocarpus spicatus
Miro	Podocarpus ferrugineus
Monoao	Dracophyllum subulatum
Pampus	Cortaderia spp
Pate	Schefflera digitata
Radiata	Pinus radiata
Rangiora	Brachyglottis repanda
Rata	Metrosideros umbellata
Raukawa	Pseudopanix edgerleyi
Rimu	Dacrydium cupressinum
Tanekaha	Phyllocladus trichomanoides
Tawa	Beilschmiedia tawa
Totara	Podocarpus totara
Tree fern	Cyathea spp Dicksonia spp
Wineberry	Aristotelia serrata
Yorkshire fog	Holcus lanatus

Birds

Common Name Used	Scientific Name
Bellbird	Anthornis melanura
Blackbird	Turdus merula
Californian quail	Lophortyx californicus
Chaffinch	Fringilla coelebs
Fernbird	Bodleria punctata
Goldfinch	Carduelis carduelis
Greenfinch	Chloris chloris
Grey warbler	Greygone igata
Hedge sparrow	Prunella modularis
Huia	Heteralocha acutirostris
Kingfisher	Halcyon sancta
Long-tailed cuckoo	Eudynamis taitensis
Morepork	Ninox novaeseelandiae
Myna	Acridotheres tristis
N.I. Fantail	Rhipidura fuliginosa placabilis
N.I. Kaka	Nestor meridionalis septentrionalis
N.I. Kokako	Callaeas cineria wilsoni
N.I. Rifleman	Acanthisitta chloris granti
N.I. Robin	Petroica australis longipes
N.Z. Falcon	Falco novaeseelandiae
Paradise shelduck	Tadorna variegata
Pied tit	Petroica macrocephala toitoi
Red Poll	Carduelis flammea
Saddleback	Philesturnus carunculatus
Shinnig cuckoo	Chalcites lucidus
Silvereye	Zosterops lateralis
Song thrush	Turdus philomelos
S.I. Kokako	Callaeas cineria cineria
Takahe	Notornis mantelli
Tui	Prosthemadera novaesee-landiae
White-backed magpie	Gymnorhina hypoleuca
Whitehead	Mohoua albicilla

Yellow-crowned parakeet   Cyanoramphus auriceps

N.I. = North Island
S.I. = South Island

Animals

Common Name Used	Scientific Name
Ferret	Mustela putorius
Hare	Lepus europaeus
Hedgehog	Erinaceus europaeus
House mouse	Mus musculus
Kiore	Rattus exulans
Norwegian rat	Rattus norvegicus
Pig	Sus scrofa
Possum	Trichosurus vulpecula
Rabbit	Oryctolagus cuniculus
Red deer	Cervus elaphus
Ship rat	Rattus rattus
Stoat	Mustela erminea
Weasel	Mustela nivalis

Extract from *N.Z. Gazette*, 12 July 1979, No. 62, p. 2096

State Forest Land Set Apart as a Dedicated Area—Pikiariki Ecological Area Notice 1979

PURSUANT to section 15 of the Forests Act 1949 (as inserted by section 2 of the Forests Amendment Act 1973, and amended by section 5 of the Forests Amendment Act 1976), the Minister of Forests hereby gives notice that the land described in the Schedule hereto is hereby set apart and dedicated for the purposes of protection, maintenance, and management of trees and other plants, and for the protection of native wildlife consistent with the proper use and management of State forest land. The State forest land so dedicated shall be known as the Pikiariki Ecological Area.

SCHEDULE

NORTH AUCKLAND LAND DISTRICT—AUCKLAND CONSERVANCY—WAITOMO AND TAUPO COUNTIES

PART Maraeroa A2, A3A, and B2 Blocks, situated in Blocks XIV and XV, Ranginui Survey District, and Blocks II and III, Hurakia Survey District: area, 457 hectares (State Forest by *New Zealand Gazette*, 1935, p. 581), as more particularly delineated on S.O. Plan 48965.

As shown on plan N. 93/2 deposited in the Head Office of the New Zealand Forest Service at Wellington.

Dated at Wellington this 3rd day of July 1979.

VENN YOUNG, Minister of Forests.

NOTES:

1. Camping or lighting of fires within the dedicated area is prohibited.

2. No felling or removal of native trees or plants or disturbance of the soil is permitted except for scientific or forest or wildlife management purposes as approved by the Minister of Forests.

(F.S. 6/1/96)

P. D. Hasselberg, Government Printer, Wellington, New Zealand—1979

DENSE MIXED PODOCARPS TYPE (L1)

General description. Before the type is described in detail with recognition of variation within, it is desirable to record the structure and composition of the type as a whole: Stands of tall mixed podocarps (principally matai and rimu, but also miro, totara, and, locally, kahikatea, Hall's totara, tanekaha, toatoa, and mountain toatoa) form a dense tier at between 70 and 130 ft, depending on exposure and altitude, which ranges from 1,500 to 2,800 ft. The number of mature trees per acre averages 40 (range 20–80) with the crowns often meeting to form a closed canopy.

Podocarp bole diameters are significantly smaller than in other major types; matai, miro, and totara are predominantly of 12–20 in. and 20–30 in. classes (at breast height) and rimu predominantly of 20–30 in. class. The lower tiers are usually not dense, but scattered or dense only in patches. Common lower-tier associates are kamahi, black maire, white maire, pokaka, mahoe, *Nothopanax* spp., *Suttonia* spp., broadleaf, Westland quintinia, other scrub hardwoods and tree ferns, while small colonies of seedling, sapling, and pole tawa occur in a few areas. Podocarp poles and saplings occur infrequently though podocarp seedlings are often well represented.

General description. Scattered large mixed podocarps averaging 14 trees per acre (principally rimu and matai but also miro, totara and, locally, kahikatea, tanekaha, and toatoa) stand as scattered emergents between 70 and 110 ft over hardwoods. A feature of the type is the mature, often overmature, condition of the podocarps, evident in large-diameter defective boles and stag-headed crowns. The lower hardwoods form three storeys; a scattered, or dense-in-patches, tier under the podocarp crowns (kamahi, *Olea* spp., hinau, pokaka, scattered patches of pole tawa) which is itself emergent over a low, dense matrix of scrub hardwoods (broadleaf, toro, *Drimys colorata*, *Coprosma* spp., *Nothopanax* spp., *Fuchsia excorticata*, mahoe, wineberry, pate, *Carpodetus serratus*, *Myrtus* spp.) and tree ferns; this on examination shows further stratification, the lower few feet being differentiated by the dominance of seedlings and saplings and by animal depletion. A constant site variation is evident on dissected terrain; there is a marked tendency for the podocarps, and many of the taller hardwoods, to be concentrated on ridges and upper valley slopes, while narrow valley bottoms and lower valley sides are dominated by scrub hardwoods (*Fuchsia excorticata*, wineberry, pate, kamahi, broadleaf) and tree ferns, with a characteristically thick ground cover of ferns (mainly *Blechnum* spp.). On the latter sites the podocarps, usually matai and kahikatea, are sparse or, in some places, absent. Another trend is apparent on this class of terrain: the podocarp stocking on north- and east-facing slopes is lighter than on south- and west-facing slopes. Podocarp poles and saplings occur infrequently, and tend to be concentrated on ridges and spurs, where the more skeletal soils inhibit the growth of suppressing scrub hardwoods and tree ferns. On ridges and spurs are also sporadic dense patches of tawa seedlings, saplings, and poles. Seedling podocarps are often well represented; these, too, occur most frequently on ridges and spurs. With rise in altitude there is a marked reduction in average podocarp stocking to 2–8 per acre and concomitant increase in the physiognomic prominence of scrub hardwoods, many of them, individually inconspicuous at lower altitudes, attaining large size and occupying unusual sites. For example, lancewood, *Coprosma* spp., and *Drimys colorata* are frequently over 6 in. and occasionally over 12 in. in diameter, and *Fuchsia excorticata* occurs on such unusual sites as high broad ridges. At the upper altitudinal limit (transition zone with *Hall's totara / scrub hardwoods* type) there is an intermittent but recognisable "dead zone" where the podocarps are sparse, many of them dead (principally matai), with many dead kamahi of tree size. Here there is a veritable jungle of scrub hardwoods and, rarely, large leptospermum with diameters up to 30 in.

PODOCARP/TAWA TYPE (M2):

General description. Large podocarps (principally rimu and matai but also miro, a few totara, and rare kahikatea) stand as scattered emergents at heights between 80 and 110 ft over dense lower hardwood tiers dominated by tawa. The average number of podocarp trees per acre is nine; they are mainly of large diameter and this and the frequent occurrence of bole defect indicate appreciable overmaturity. The hardwoods form three moderately dense, rather ill defined, lower storeys. Underneath the scattered podocarps, which often occur in clumps, are tawa and kamahi with occasional maire, hinau, and a few small miro. Beneath these are two tiers, the lower differentiated by the prominence of seedlings and saplings and by an appreciable degree of depletion by animals; both these tiers are dominated by young tawa and contain tree ferns in abundance, with many scrub hardwoods and rather scanty regeneration of hinau, maire, and podocarps. Near the upper altitudinal limit the stocking of tawa decreases and scrub hardwoods become much more prominent, with entry of quintinia. In dissected terrain there is a constant site variation; in gully bottoms and on lower gully sides the podocarp stocking falls to about two trees per acre and tawa is absent; over quite large areas the podocarps may also be absent. These sites are dominated by tree ferns and scrub hardwoods (broadleaf, *Nothopanax* spp., *Carpodetus serratus*, *Drimys colorata*, *Fuchsia excorticata*, wineberry, rangiora, large-leaf *Coprosma* spp., mahoe, *Hoheria populnea*); there is usually much kamahi, and occasional moribund larger trees of this species protrude from the scrub complex. Effective regeneration of podocarps and tawa is lacking on these sites, though scattered suppressed seedlings occur among the prolific fern growth (*Leptopteris* spp., *Blechnum* spp., *Dryopteris pennigera*, young tree ferns) which provide a good floor cover. On all other sites a multi-storey structure is evident.

APPENDIX 4

Podocarp Density

The podocarp density figures were obtained directly from National Forest Survey plot sheets. A specimen plot sheet is appended (Appendix 6). Map 11 indicates the location of these plots; note plot sheets for some of the plots indicated were not found.

These plot figures were collected some time ago (1947-1948), however there appears to be only minor change in the areas they cover. This change being occasional windthrow and stems removed from the Perham's Avenue area during a 'creaming' operation.

The figures are not meant for statistical analysis, but reinforce patterns in podocarp composition observed from the ground and from aerial photographs. These patterns are summarised in section 2.4 and map 2.

APPENDIX 5

Podocarp Stems Per 0.4 Hectares: Figures From The National Forest Survey

Line 23 (1947)

Species	Plot Number 33	33x
Matai	4	8
Totara	-	1
Rimu	4	2
Kahikatea	-	5
Miro	2	-
Total	10	16

Line 23X (1948)

Species	Plot Number 31	31x	32
Matai	45	14	14
Totara	14	1	1
Rimu	8	13	1
Kahikatea	5	3	1
Miro	4	3	-
Total	76	34	17

Line 24x (1948)

	Plot Number			
Species	31	31x	32	32x
Matai	34	69	31	41
Totara	10	2	19	10
Rimu	-	3	3	2
Kahikatea	4	-	8	6
Miro	2	-	4	-
Total	50	75	65	59

Line 25x (1948)

	Plot Number							
Species	30	30x	31	31x	32	32x	33	33x
Matai	55	43	32	13	8	25	17	6
Totara	7	4	6	-	-	3	-	7
Rimu	17	38	6	10	16	21	27	22
Kahikatea	1	1	6	-	-	-	1	9
Miro	4	-	2	-	-	6	-	11
Total	84	85	52	23	24	49	44	65

Photo. [illegible]	A. 3 × 2.	Merchantable.	Cull.				
[illegible]	Species.	[illegible]	Species.	[illegible]	[illegible]	[illegible]	[illegible]
Alt. [illegible]			[illegible]				
Aspect: W	[illegible]	[illegible]	[illegible]		"		
Slope: 2°		[illegible]	[illegible]	[illegible]			
Type. [illegible]	[illegible]	[illegible]					
P1.		[illegible]					
F. / D. / N.P.		[illegible]					
		Podo. [illegible]					
		[illegible] Nil.				0	
Virgin. / Worked.		[illegible]					

B. 1 × ½	Merchantable.				Cull.	
Species.	4"–6"	6"–8"	8"–10"	10"–12"	Species.	4"–12"
			427			

Camp/3

Fire.	

Animals.
Goats
Pigs.

Availability.		
A.	D.	N.A.

C. ½ × ¼ Species.	Merch.	Reg.	Sec.

Soil.

A_0.

A_1

B_1.

Top.

Association and Remarks.

PODOCARP FOREST UNDERTIER KAMAHI & YOUNG [illegible] AND PODOCARP REGEN — PEPPER-WOOD & SCHEFF. & GROUND FERNS.

Tenure: [illegible]

[illegible]

APPENDIX 7

Criteria for the Allocation of Conservation Values; Used by the Wildlife Service in the West Taupo Forests. (Imboden,1978).

Outstanding

- presence of an endangered species listed in the Red Data Book of the International Union for the Conservation of Nature and Natural Resources.
- presence of an isolated viable population of an endemic species with restricted distribution and of limited abundance.
- largely unmodified habitat type not represented elsewhere in the country to the same extent and large enough to support self-sustaining populations of all plant and animal species which are part of this community.

High

- presence of an uncommon, discontinuously distributed species not adequately and safely represented elsewhere in the region.
- presence of a species whose abundance and distribution has elsewhere significantly declined due to man induced habitat alterations.
- large example of an unmodified habitat type which is typical for the region and has been much reduced through human influences.

Moderate

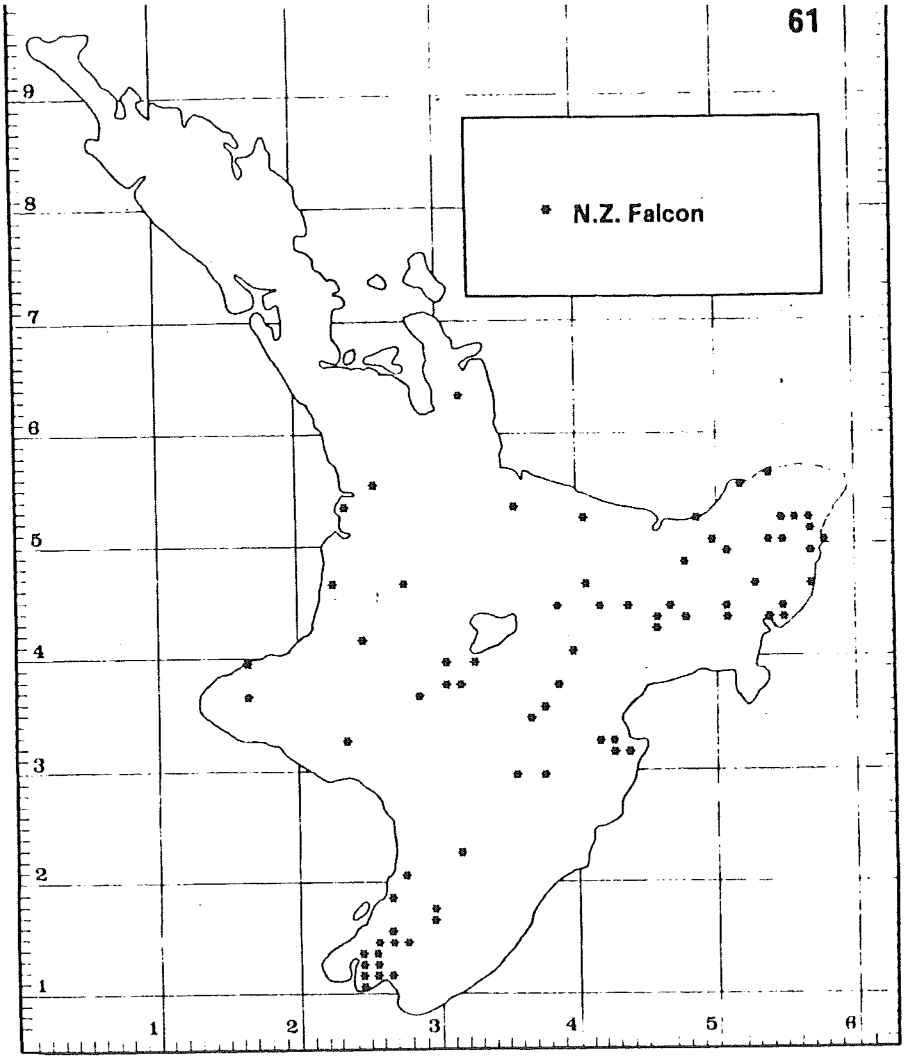
- areas supporting good numbers of the common wildlife species typical for the region
- all forest and wetland habitats not otherwise classified, either unaltered by man or still showing much of its original structure.

APPENDIX 8

Bird Distribution Maps

The maps appended do not show abundance but merely distribution. They were compiled between the years 1969 and 1976 under the guidance of the Ornithological Society of New Zealand. There are omissions (e.g. Kokako on the Coromandel Peninsula) which are probably included on updated maps; these maps were not available, unfortunately.

Source: Bull, P.C., Gaze, P.D. & Robertson, C.J.R. (1978). Bird Distribution In New Zealand; A Provisional Atlas 1969-1976. The Ornithological Society of N.Z. Inc.


61
N.Z. Falcon
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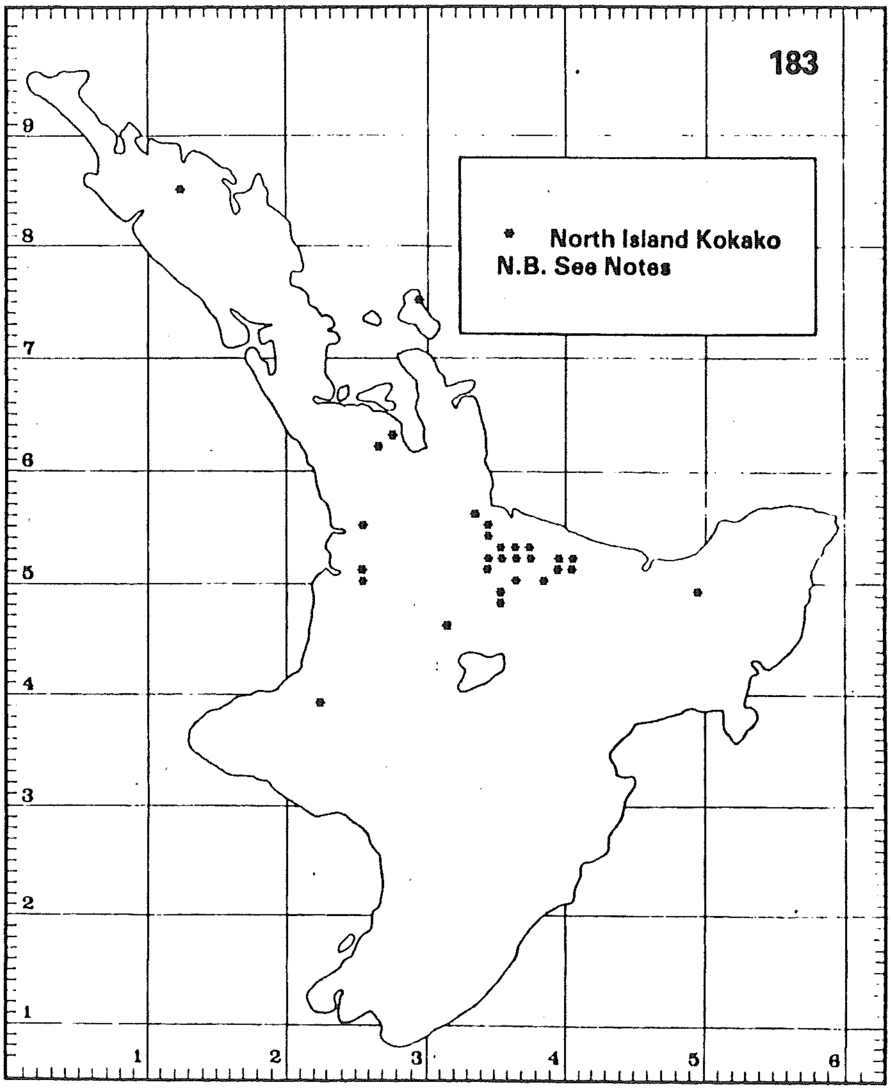
183
North Island Kokako
N.B. See Notes
1
2
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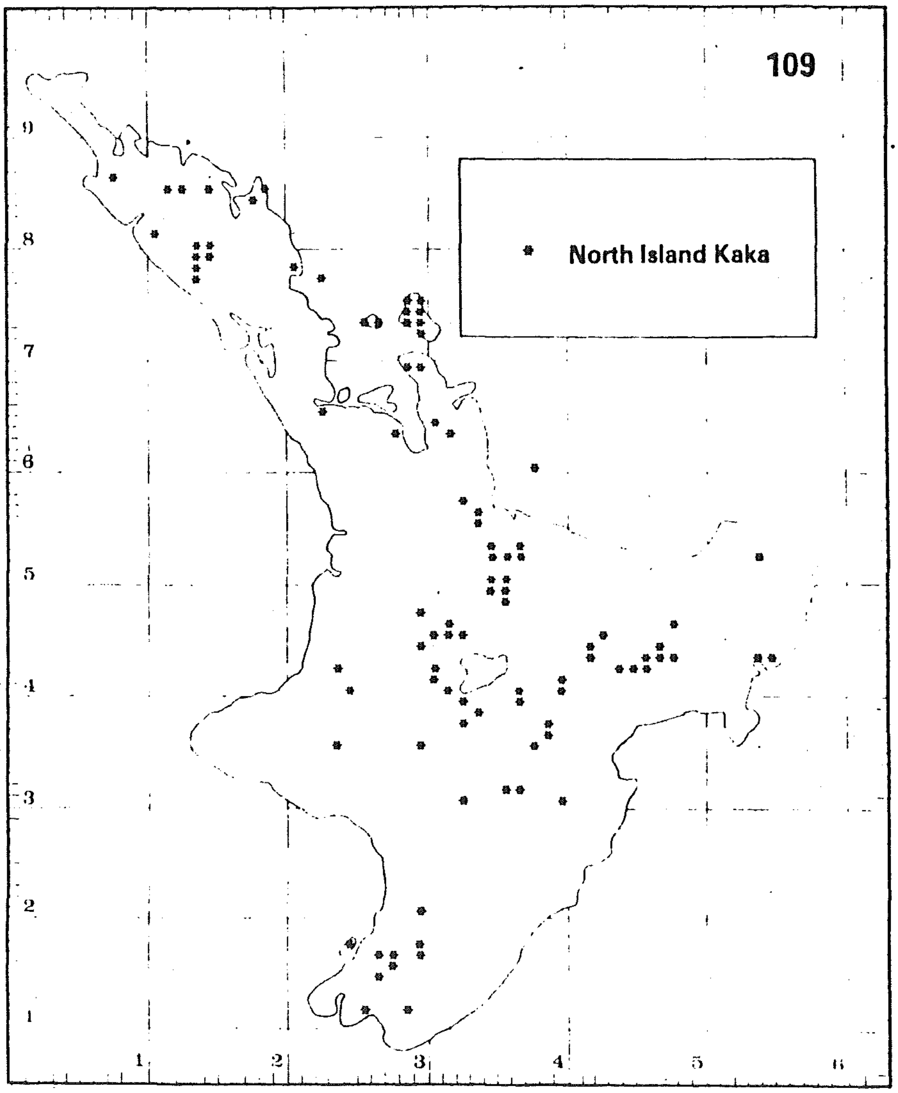
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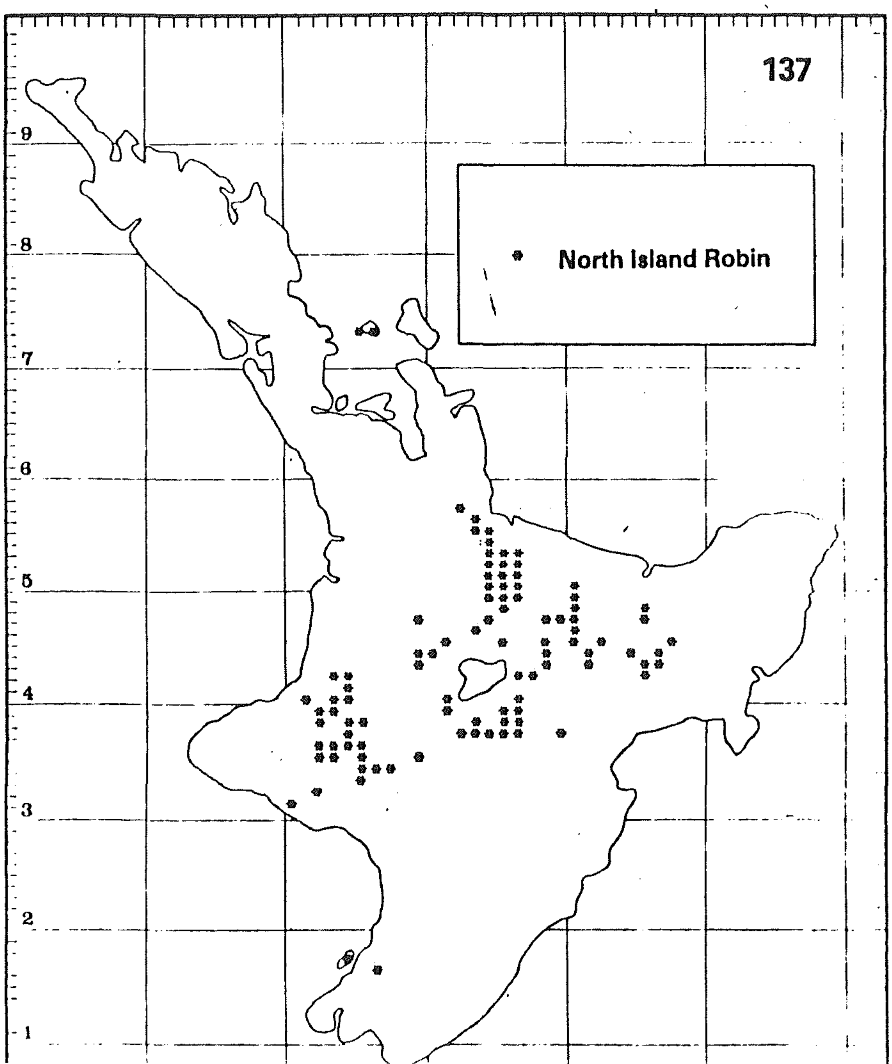
North Island Kaka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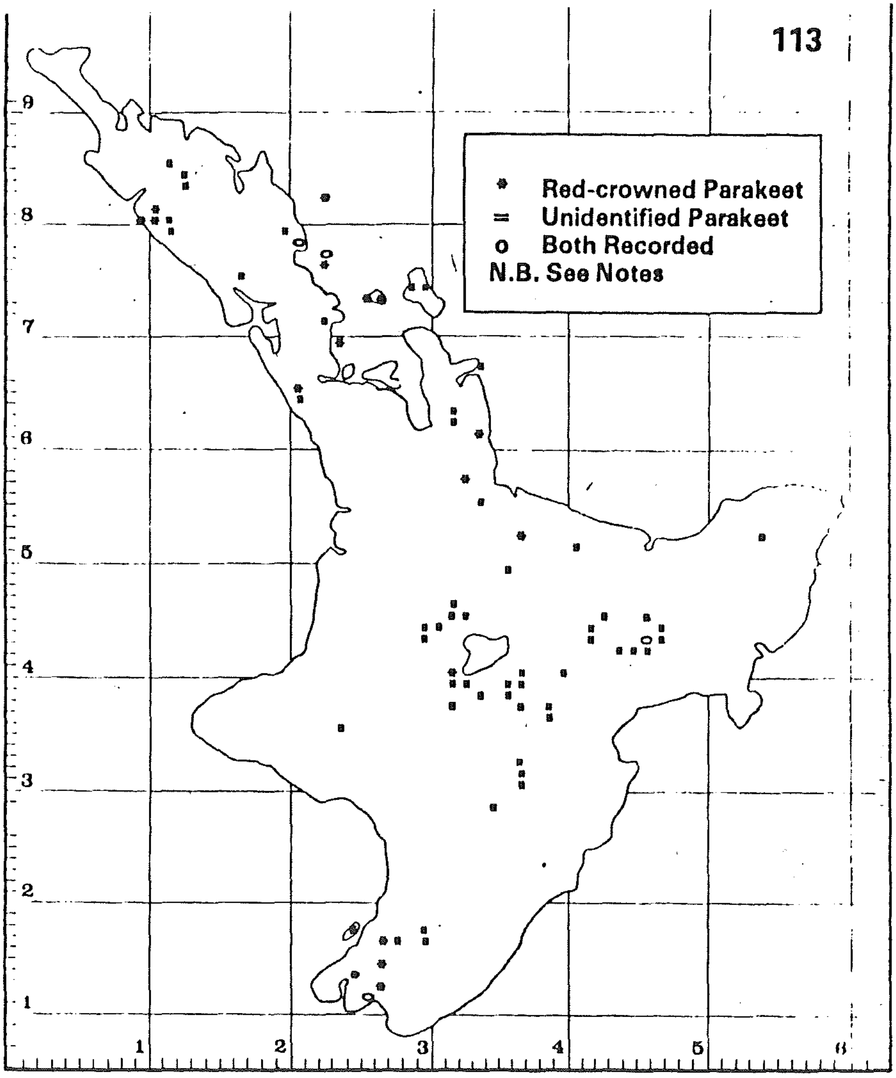
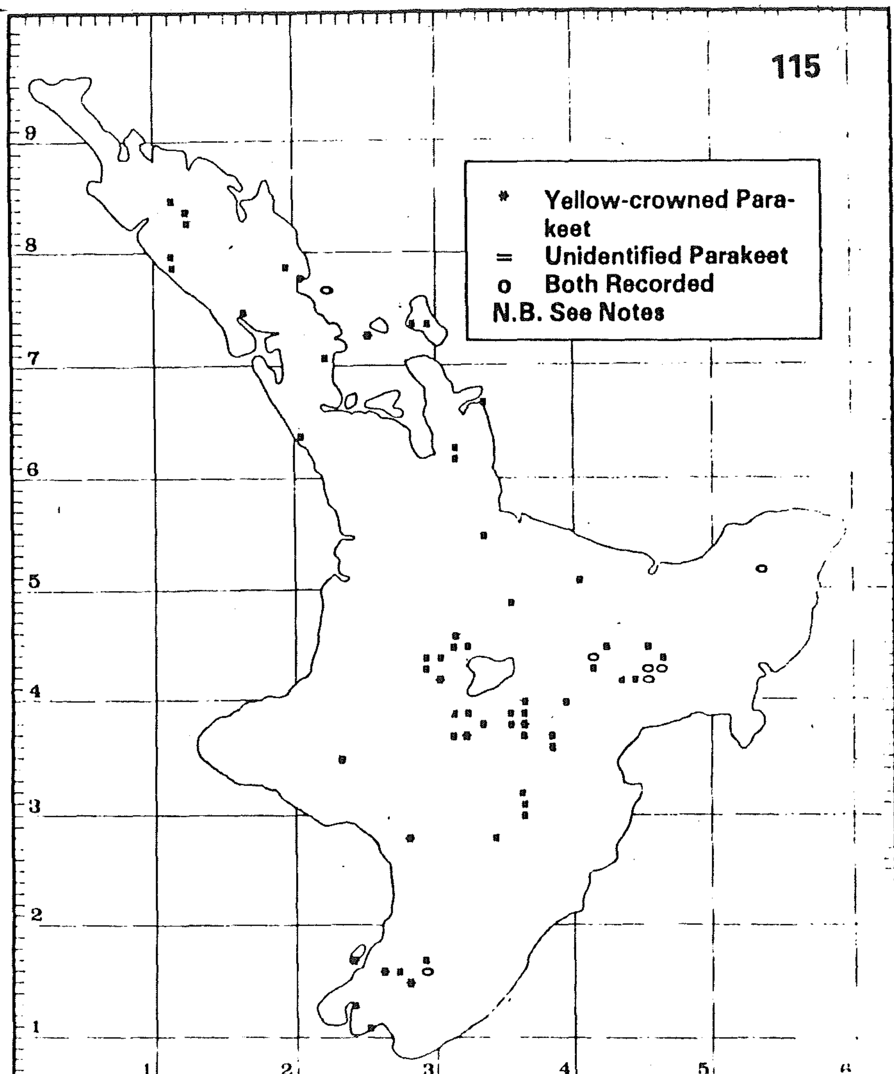
North Island Robin


113
Red-crowned Parakeet
Unidentified Parakeet
Both Recorded
N.B. See Notes


115
Yellow-crowned Parakeet
Unidentified Parakeet
Both Recorded
N.B. See Notes

APPENDIX 9

Kokako Mapping Exercise

The aim of this mapping exercise was to obtain an estimate of the total kokako population in Pikiariki and to identify areas where their density is greatest. The method does not give data capable of statistical analysis.

Method

Over a series of seven days from 15/1/84 Pikiariki was surveyed for kokako:

(1) Observations began between 6.00 and 7.00am as soon as entering the bush.

(2) After a five minute listening period a kokako song was played for five minutes followed by another five minutes of listening. All kokako seen or heard were recorded.

(3) If birds were heard the area was searched to determine whether a single or a pair were present.

(4) Observations were complete at a station when birds had been identified, or a search had failed to locate the source of a call, or if no birds were seen or heard after the fifteen minutes had elapsed.

(5) The next station was approximately 250m from the last and on a predetermined compass bearing. The distance was paced out.

(6) Once the station was reached observations recommenced.

(7) All observations ceased when a predetermined location was reached or otherwise at midday.

Points On The Survey Technique

(a) Kokako are known to be particularly vocal during the dawn chorus (Hay,1981). Later in the day they tend to sing less, thus some bias may occur because of the time of day and birds may not be located later in the day. To a degree this was standardised by restricting observations to the morning.

(b) There are differences in dialect between kokako of different localities. This may result in varying responses to a song played-back, and ideally should be standardised by using a recording of the 'mew'. However, Pikiariki is small and kokako are concentrated in several small areas, therefore response should not vary unacceptably due to dialect differences. Reaction to the recording was in some cases very strong with birds moving down towards the tape-recorder.

(c) Although the reserve is only narrow it is possible that transects did not cross a kokako territory or that a territory did not contain a station. Thus birds may have not reacted to the recording and may have been missed.

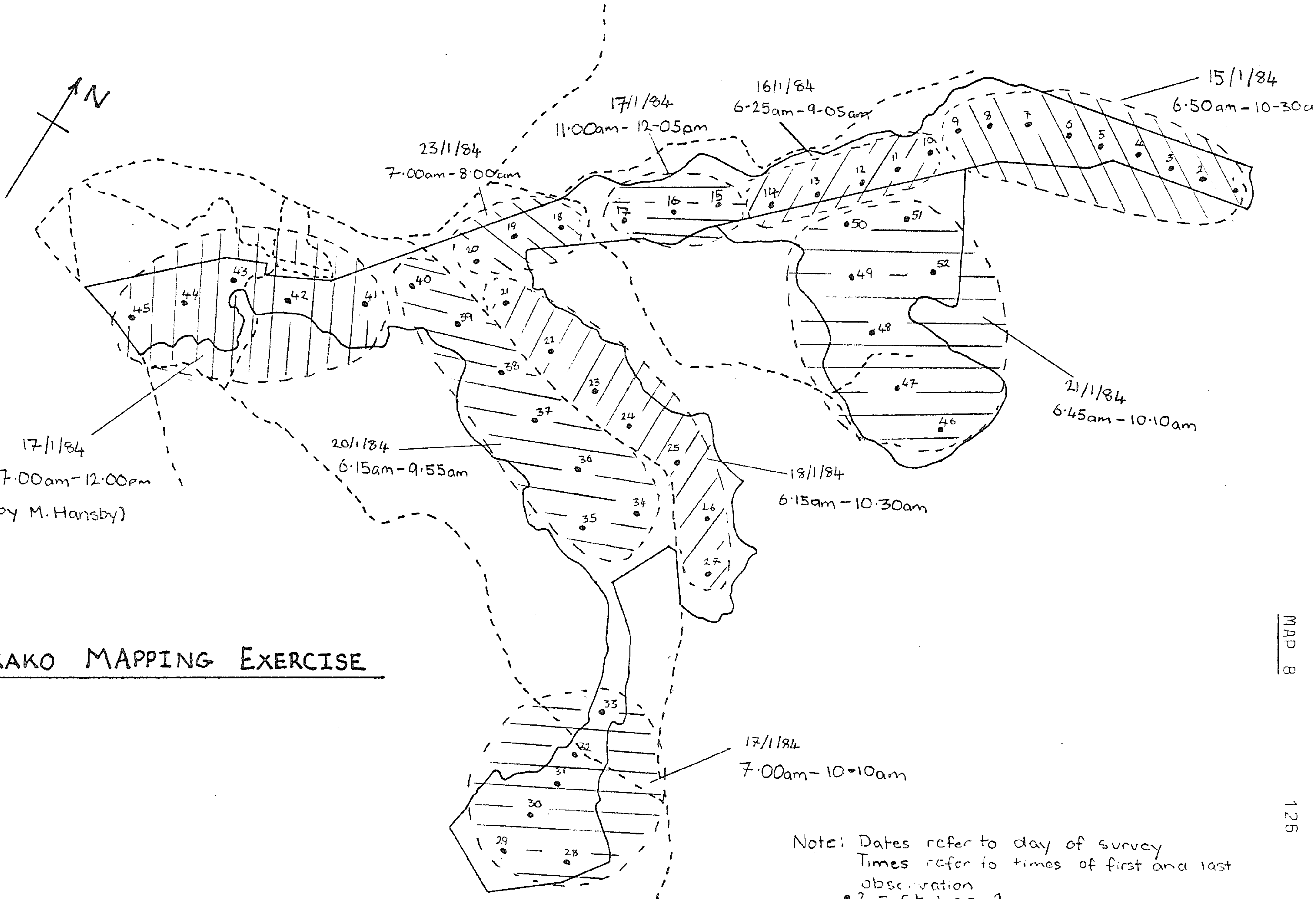
(d) Differences in weather may affect kokako conspicuousness (Crook _et al_, 1971). The time available did not allow for this to be standardised.

(e) Play-backs of poor quality may affect kokako response (Crook _et al_, 1971). The recording used was of good quality; it was recorded by T.V. New Zealand in the Study Area. The tape-recorder used was a good quality stereo machine.

(f) Double counting may have occurred. It is possible that birds recorded on each side of Perham's Avenue as different birds may in fact have been the same bird or pair, i.e. birds may have flown across the road. Birds may have followed the recording at successive stations, and thus it was sometimes difficult to determine whether these were new birds or the one previously recorded.

All sightings were recorded and decisions made where any of the above problems occurred.

KOKAKO MAPPING EXERCISE



Note: Dates refer to day of survey
Times refer to times of first and last observation
• 2 = Station 2

Scale 1:20000

MAP 8

APPENDIX 10

Legend for Soil & Water Map (& See Map 4)

Parent Material

Kt	- Kaharoa & Taupo Ashes
Mo	- Ashes older Taupo Ash
Vo	- Welded Volcanic Rocks

Slope

A	- $0-3^{o}$	
B	- $4-7^{o}$	
C	- $8-15^{o}$	C+D compound - first dominates
D	-$16-20^{o}$	
E	-$21-25^{o}$	
F	-$26-35^{o}$	
G	35^{o}	

Soil

Toi^{+} & $ToiH^{+}$	- Tihoi Series (Podzolised yellow-brown pumice soils)

Erosion

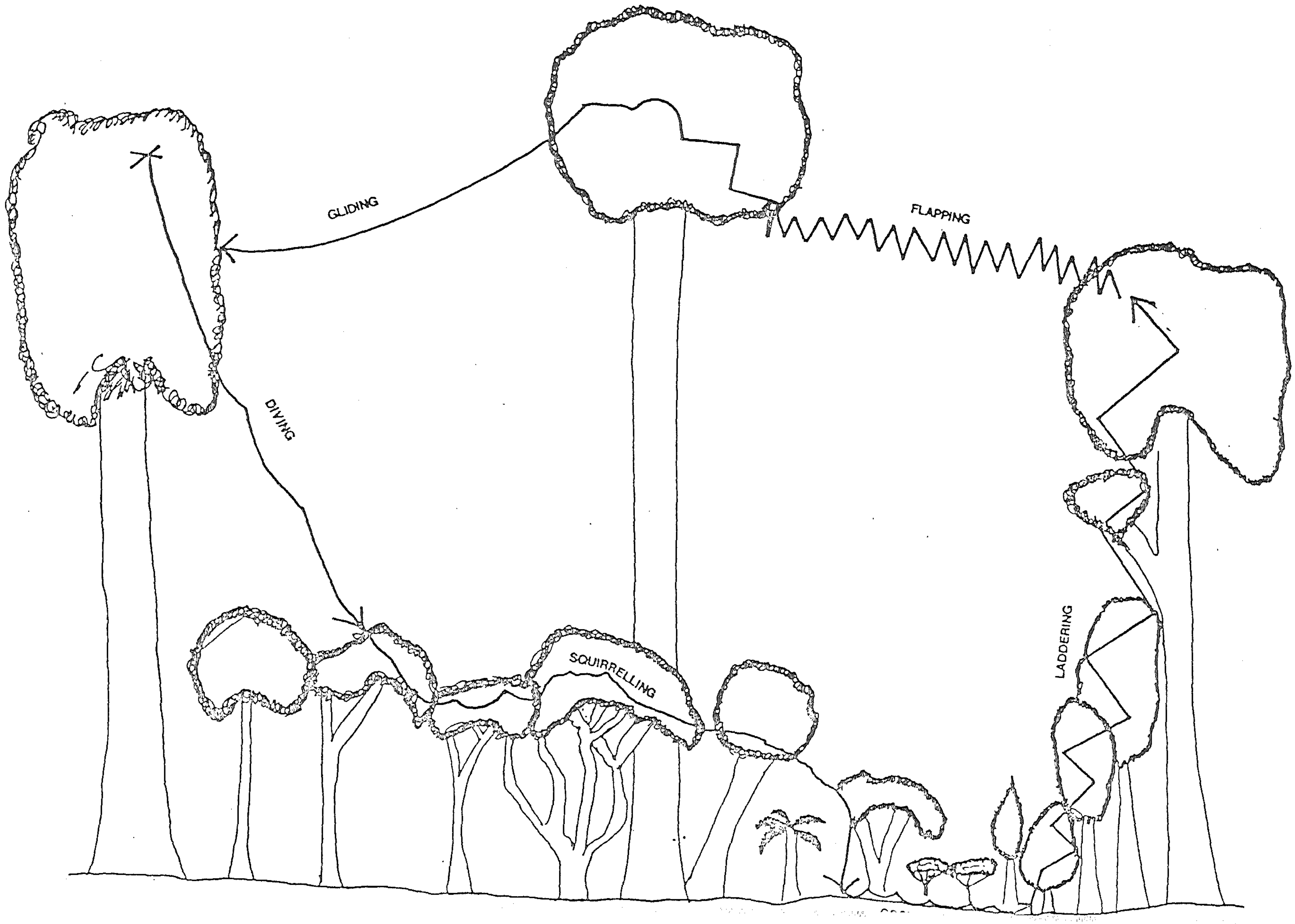
e	- erodability
s	- soil limitation with rooting zone

LUC Classification

Class 1V
Subclass e
Unit 7

Source: MOW, 1975 Land Resource Inventory, Maps and Extended Legend. Taranaki - Manawatu Region and Bay of Plenty - Volcanic Plateau Region.

SCHEMATIC DIAGRAM OF COMMON PATTERNS OF KOKAKO MOVEMENT



Source: Hay, J.R. 1981: The Kokako. Forest Bird Research Group. Unpublished Report.

APPENDIX 12

Cyclic Regeneration of Podocarps

The following sequence may be seen in scattered podocarp forest (podocarp/kamahi/scrub hardwoods type): (Beveridge,1973).

(1) Windfall of a large overmature podocarp.

(2) Invasion or increase of tree ferns until a colony of rhizomatous *Dicksonia squarrosa* is formed. The dense litter inhibits terrestrial recruitment of all podocarps and hardwoods.

(3) Development of epiphytic growth of hardwoods, particularly kamahi, on tree fern stems.

(4) Suppression and death of most of the tree ferns by hardwoods, and development of kamahi to a large size when it becomes a suitable perching tree for birds, particularly pigeons.

(5) Recruitment of podocarp seedlings mainly from bird dispersed seed.

(6) Development of a podocarp sappling group as the kamahi thins and dies. Windfall of adjacent podocarps at this stage may enlarge the gap and hasten development of the podocarp group.

Source: Beveridge, A.E. 1973. Regeneration of Podocarps In A Central North Island Forest. N.Z.J. Forestry 18(1): pp23-35.

APPENDIX 13

Stocking Rates For Podocarp Seedlings

Aim to replace the removed or windthrown podocarp stems; such that composition is around 80% rimu and 20% kahikatea, totara and matai. This represents the approximate proportions of timber removed from these sites (NZFS.1982). The final forest composition is not known as podocarp and hardwood regeneration will probably occur in conjunction with artificial revegetation. The resulting forest system should however be one in which kokako may feed and reproduce naturally.

Assessments by the Forest Service have shown that on average, 11 podocarps/ha were removed in selectively logged sites and 20 podocarps/ha in cutover areas.

Specifications given for podocarp revegetation in Pureora are:

- 1 in 3 trees will be of good vigour and form
- 1 in 3 trees will survive

  thus to get one good tree 9 must be planted.
- trees planted in groups of 3 for mutual shelter
- a minimum distance between groups of 10m.

In selectively logged areas; 9x11 = 100 trees/ha thus 33 groups/ha.

In cutover and badly windthrown areas 9x20 = 180 trees/ha thus 60 groups/ha.

Note: It is important that large numbers of seedlings are planted so that natural selective forces may operate; some natural regeneration will also be important.

Source: Pureora Forest Park Indigenous Re-establishment Work Plan 1982-1987. NZFS Internal Report.

APPENDIX 14

Re-establishment Trials Pikiariki

Bush Nurseries - Trial A818

Six bush nurseries were established in July 1978 to investigate the practicality of producing seedlings for transplantation by various methods but with natural regeneration.

Methods involved:

Nursery 1: spreading a layer of pumice on site and raking in totara seed.

Nursery 2: spreading a layer of pumice on site and sowing rimu seed.

Nursery 3: ripping and then raking the soil; then sowing half the area in rimu the other half in kahikatea.

Nursery 4: spreading a layer of pumice and rely on natural rimu seedfall for regeneration.

Nursery 5: Seed bearing rimu branches and forest duff was raked onto the site.

Nursery 6: topsoil was raked and seed bearing rimu branches were spread over the site.

By 1983 it was decided that this operation would not be commercially viable for producing seedlings because:

(1) Growth rates were slow
(2) Survival was low
(3) Weed competition was limiting
(4) Stock of better quality and of greater quantity could be produced more economically at Cambridge Nursery.

It was thus recommended that the emphasis be shifted from that of a silvicultural trial to an ecological trial.

Source: Taylor, S.M. Progress Reports on Trial A818; Bush Nurseries Pureora. NZFS Internal Report.

Artificial Establishment of Podocarps Trial A810/1

Four areas were subjected to different treatment to investigate the feasibility of indigenous re-establishment.

General Methods Involved

Block A - Planting of podocarp and hardwood seedlings on a cutover site, and later releasing.

Block B - Planting of an indigenous nurse crop for later podocarp establishment.

Block C - A natural regeneration area.

Block D - Establishment of a *Eucalyptus delegatensis* nurse crop and a small area of tree lucerne (*Cytisus proliferous*).

Findings

In Block A it was found that;

(1) Browse is a problem

(2) Bare pumice soil is the most appealing site for those planting but of poor fertility.

(3) Weed growth tends to indicate better soil fertility therefore better sites for planting.

(4) On these sites weed competition may be limiting and should be controlled.

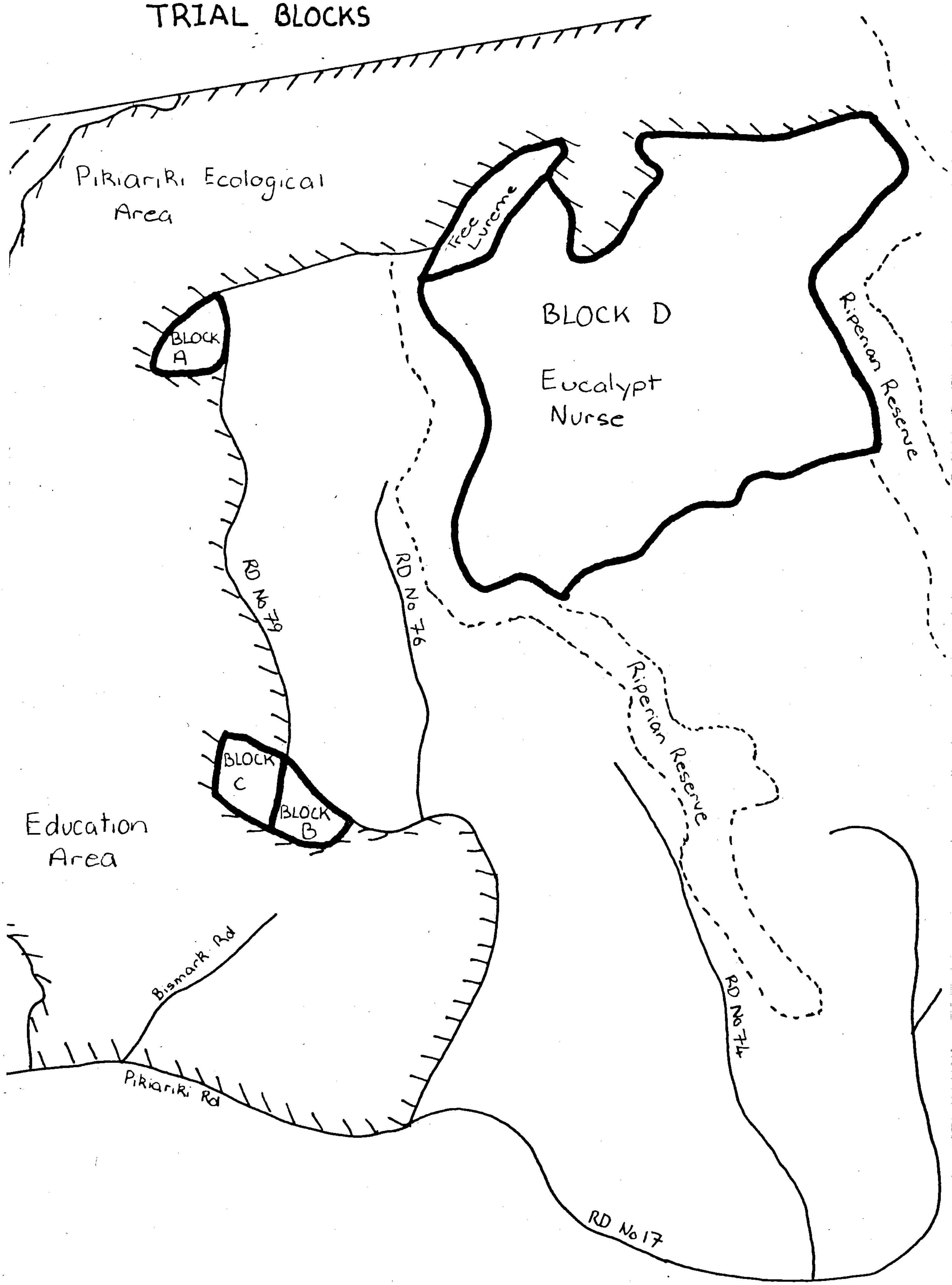
Hardwood survival was low in Block B thus the site was re-planted, in 1982 (originally in 1980). On the neighbouring control Block C natural regeneration of hardwoods was occurring and there appeared to be little difference between the two sites. Hardwood plots in Block B were however facing competition from pampus grass and yorkshire fog.

In Block D tree lucerne, which seemed eminently suitable as a nurse crop, was badly browsed.

In the remaining area various patterns of eucalypt planting were used to test their suitability as a nurse crop and the possibility of later extraction.

INDIGENOUS RE-ESTABLISHMENT TRIAL BLOCKS

MAP 9



Two years later, in 1980/1981 totara, rimu and kahikatea seedlings were planted in different patterns amongst the nurse crop. In part of the Block a chemical weed control trial was incorporated.

The results to date show:

(1) That *E. delegatensis* may not be the best nurse species for dry frosty gullies where *E. regnans* may be better.

(2) Hot dry winds and frosts are periodically, likely to cause seedling mortality (a good nurse cover should help reduce this and blanking may be necessary).

(3) That weed competition, particularly bracken fern, may be a problem.

(4) That chemical weed control was generally unsatisfactory, however another trial (WP IFM 9/20093) indicates that Roundup plus Simazine may have been the most effective treatment, if applied post-planting, for most, if not all, the different weeds encountered.

These trials are still only at an early stage and much may still be learnt from them.

Source: NZFS 1978-1983 Internal Reports on Pureora Indigenous Re-establishment Trial A810/1, A810/2 and A810/3.

APPENDIX 15

Territory Mapping Exercise

The aim of this exercise will be to ascertain the approximate territories occupied by kokako pairs. Trapping operations implemented within these territories should offer protection to any nests. While the territories are being mapped observers will also be watching for nests.

Method

This method is a simplified version of that used by Hay (1981). The areas to be surveyed will be those indicated on map 3 as having birds present.

Once observers have located a bird they will follow it until it is lost from view. Approximate location of sitings will be noted as well as other features; that is single or pair of birds, any nests and any signs of aggression. Sightings of any predators may also prove valuable.

Observations should begin at daybreak so that birds will easily be located when the dawn chorus commences. The exercise will begin in late November and continue until trapping operations begin in early January.

Re-Surveys

At the beginning of every trapping season the entire reserve should be surveyed using the method described in appendix 9 and the above territory mapping exercise applied accordingly. This is important as it will allow for any kokako dispersal, which may indicate improved habitat, or successful reproduction.

APPENDIX 16

Stoat Trapping Procedure

The fenn trap (MK IV) operates in a tunnel a little larger than the trap itself. King and Edgar (1977) describe three important functions of the tunnel:

1) To orientate the stoat relative to the trap so the jaws close across its back.

2) To disguise the trap and protect it from weather and human interference (i.e. accidental).

3) To keep out large birds and non-target mammals.

Procedure

(1) The trap is placed in a shallow depression in the ground.
(2) The treadle is covered with leaves.
(3) Felix fish cat food (bait) is placed on the trap.
(4) The trap is pegged to the ground with a chain.
(5) The tunnel is placed over the trap so that the trap is in the centre.
(6) The tunnel may be camouflaged with leaves. This is important where human interference is likely (i.e. curiousity).
(7) Traps must be kept clear of twigs, leaves etc.
(8) Traps should be oiled, sprung and reset occassionally.
(9) Traps will be more concentrated around nests, tracks and forest edges than in the forest interior.
(10) Traps will be placed along lines and located by red cruising tape tied to neighbouring vegetation.
(11) Traps will be checked every second day and bait replaced. If stoat kills are high, however, daily checks will be necessary.

(12) Where individual traps are consistently unsuccessful they may be re-deployed.

(13) Any mustelids trapped should be collected and frozen for later examination of gut contents.

Source: King, C M & Edgar, R L 1977. Techniques For Trapping and Tracking Stoats (*Mustela erminea*); a Review and a New System. NZ Journal of Zoology 4: pp 193-212.

APPENDIX 17

Rodent Poisoning Procedure

Method as used by Innes (1982;1984).

(1) Identify poisoning area

(2) Position 'talon' poison at 30m intervals on a grid throughout the area, ensuring that tunnels are pegged firmly in position over the bait.

(3) Mark the position of tunnels with cruising tape on neighbouring vegetation.

(4) Check baits at three-daily intervals and replace baits which contain less than a fatal dose of poison i.e. approximately 5g of bait. As bait takes decline checks may be reduced to weekly intervals.

(5) Cease replacement when bait is no longer taken.

This operation will be carried out in conjunction with stoat control. Logistical planning should ensure that these two operations are co-ordinated to minimise time spent in each area; similarly with surveillance methods.

Innes (1984) reports that possums had interferred with the talon bait even after a cyanide operation to reduce their numbers. To minimise this disturbance the tunnels will be pegged to the ground and possum control will commence prior to predator poisoning.

Sources: Innes, J. 1982. Investigations Into Kokako Control At Pureora. An unpublished NZFS report on Work Plan PF82/3.

Innes, J. 1984. Attempted Control of Kokako Predators In Pureora Forest. A draft for Forest & Bird.

APPENDIX 18

Tracking Tunnels

Tracking tunnels will give an index of animal numbers, showing population trends and indicating relative differences in animal numbers between a poisoned (or trapped) and a non-poisoned area.

Innes (1984) used the area 'B' as a control for his trapping operations in area A (see Map 10). This area is similar to areas where the main concentrations of kokako are found and despite differences in podocarp density will provide a suitable comparison for these control operations as well.

Low stoat numbers have meant that their tracking indices have not been statistically significant in the past, however those for rats and mice have been reasonable. Tunnels have been set high up in trees, however Innes (1984) found very few tracks in these. All efforts will therefore be concentrated on ground tunnels.

The method to be used is that described by King and Edgar (1977) and used by Innes (1984) in Pikiariki. It involves the use of wooden open-ended tunnels, 60cm x 9cm x 9cm, which contain a metal base-plate. In the centre of this base-plate is an ink-pad and sensitized tracking papers are at each end. The ink used is a saturated solution of Ferric Nitrate in Polyethylene Glycol, while the papers are treated with a solution of Tannic Acid in methylated spirits. The species of animal may easily be identified from the sharply defined indelible prints they leave.

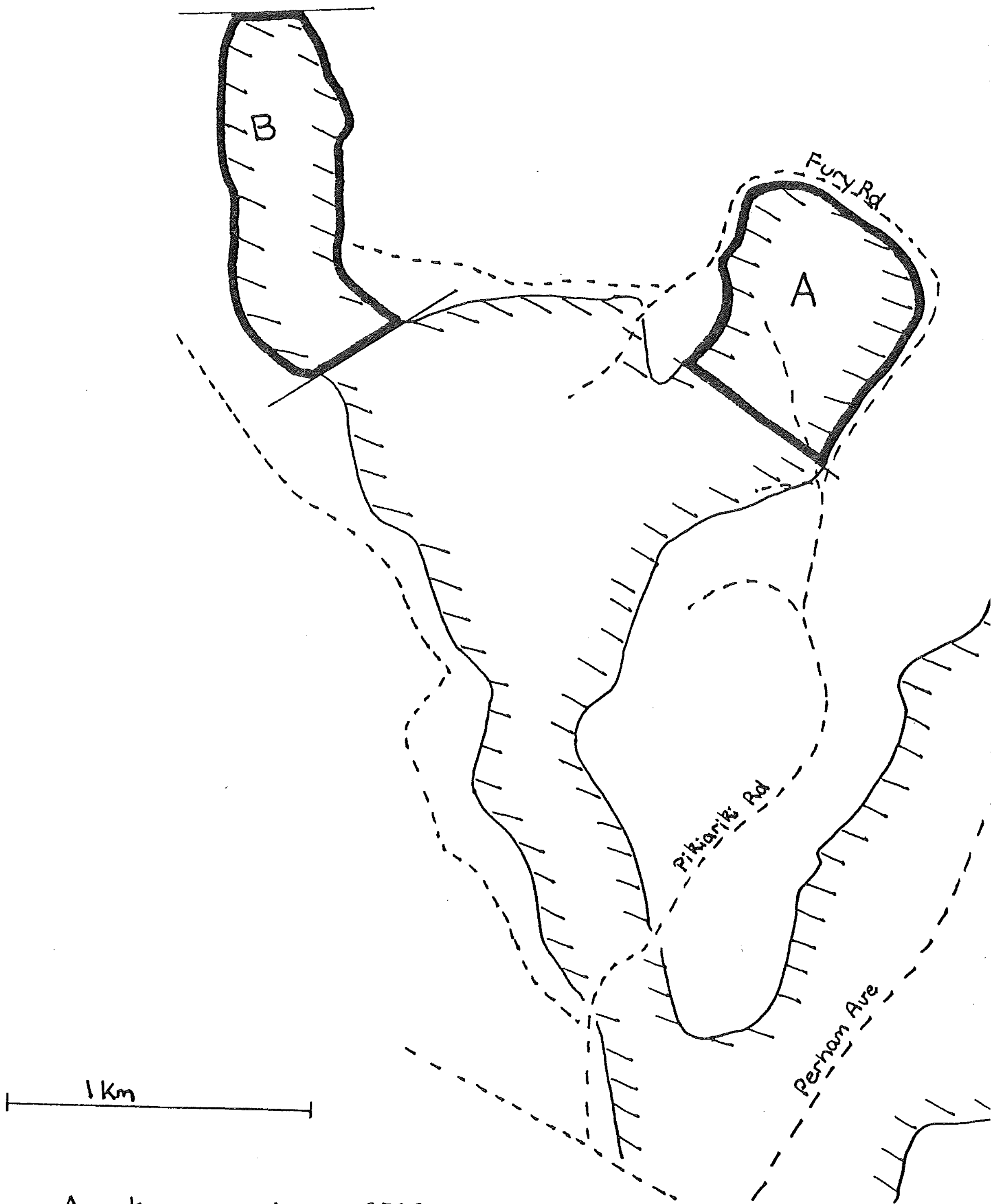
Procedure:

(1) Establish tunnels in late December or early January on a 100 metre grid.

(2) Inspect the tunnels monthly until the end of February or until March if indices in the poisoned area are still significantly lower than in the control area 'B'.

MAP 10

PREDATOR CONTROL AREAS - 1982/83



A - trap & poison area

B - untrapped - 'control area'

(3) Paper and ink will be renewed at each inspection.

Note: If resources are available then valuable information may be obtained by continuing the tracking until the indices in the control and poisoned areas return to pre-operation levels. This would probably be around August (Innes,1982).

Analysis

Any significant reduction in rodent populations may be ascertained using a Chi^2 test on before and after indices and by comparing slopes of regression lines before and after the operation.

The following formula gives an index of abundance:

$$I = \frac{\text{Number of tunnels with tracks}}{\text{Total number of tunnels last checked} \times \text{number of days}} \times 1000$$

Sources: Hay, J R 1981. The Kokako: Forest Bird Research Group unpublished report.

Innes, J 1982. Investigations Into Kokako Control At Pureora. An unpublished NZFS report on Work Plan PF 82/3.

Innes, J 1984. Attempted Control of Kokako Predators In Pureora Forest. A draft for Forest & Bird.

King, C M & Edgar, R L 1977. Techniques For Trapping and Tracking Stoats (*Mustela erminea*); a Review and New System. N.Z.J. Zoology, 1977, Vol. 4; pp 193-212.

APPENDIX 19

Tagging Kokako

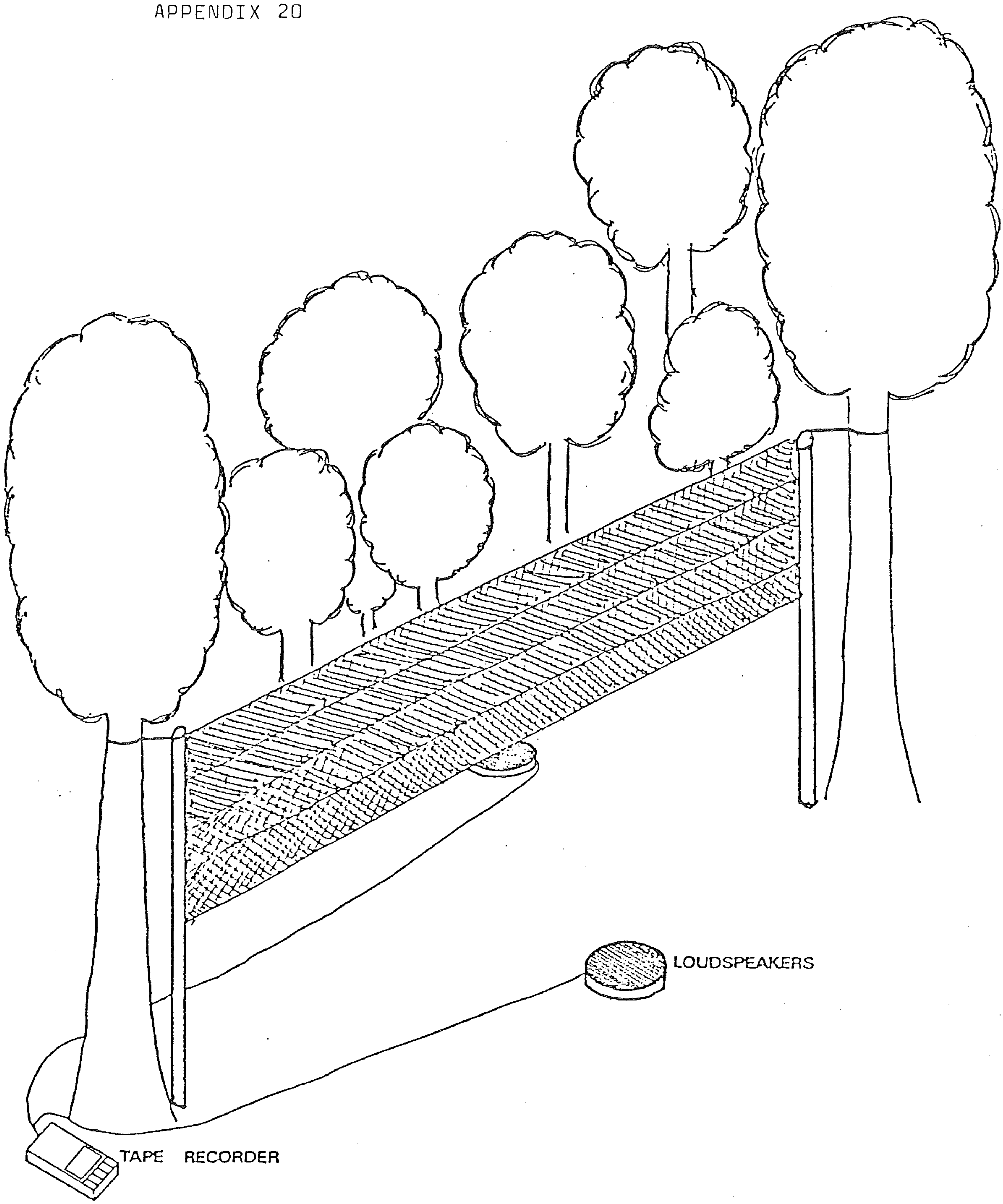
The following method was used by Hay (1981) to capture kokako.

Mist nets were placed at low points in the canopy and kokako were lured to the net by playing back their own calls on a tape recorder. A net mesh size of 2½ inches (6cm) was used. The apparatus was constructed as in Appendix 20. Each end of the net was attached to a pole, and pulleys were rigged up high in trees. Ropes were passed through the pulleys and were attached to each end of the poles enabling easy lowering and raising of the net.

Kokako chicks, however, are better caught with a trout landing net. After leaving the nest they tend to be ungainly and may be netted when close to the ground (J Innes *pers comm*). Coloured leg tags will enable the bird to be easily identified by observers.

Source: Hay, J R 1981. The Kokako. Forest Bird Research Group unpublished report.

APPENDIX 20



MIST - NET SITE

Source: Hay, (1981)

APPENDIX 21

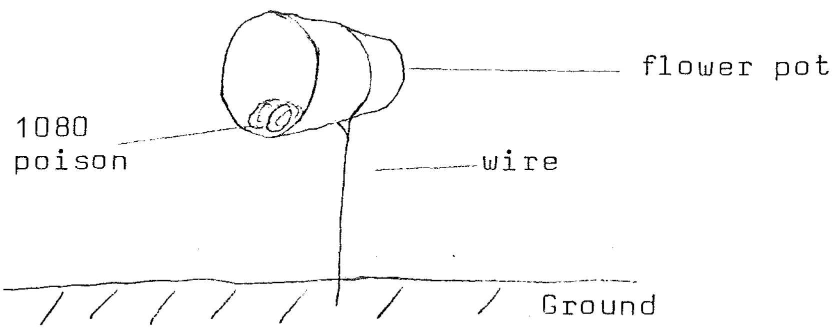
1080 Operation Used in Pikiariki To Control Possums - 1984

Concern has been voiced about possums spreading bovine T.B. onto farms adjacent to Pikiariki. In response to this concern a poisoning operation was conducted in 1984. This was done by hand and only along the forest margin because of concern for bird-life.

The operation involved:

(1) Around the village and along the fenceline, between farm and forest, 1080 was hand-laid on spitz or in feeding stations.

NB: Spitz are turned over earth.
Feeding stations were flower pots elevated on wire;



(2) Away from Pureora Village Mapoua pellets were hand laid up to 30m into the bush.

Source: R Guest pers comm., 1984.
J Innes pers comm., 1984.